See 9-Year Index, p. 37-A

Forest Products Journal

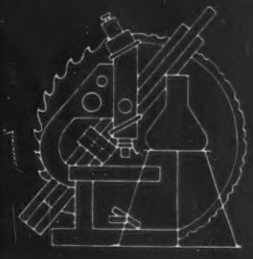

Photo courtesy of National Homes Corp.

Prefabricated Home Industry—America's Fastest Growing User of Wood—See Pages 25–A, 27–A

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OMNIBUS OF ADHESIVES

You can choose exactly the right, top-grade adhesive for almost any wood-bonding application from Cyanamid's omnibus of thermosetting resin adhesives. With these adhesives you'll also receive the benefit of technical knowledge, skill and service. Our sales representatives have had practical working experience with all these resins. Their friendly help is at your disposal.

Urac 180 – General purpose, urea-formaldehyde resin in water solution. High-solids solution (66% P.M.M.A. Method) for drum, tank-car or -truck shipments. Catalysts and hardeners are available for all wood-bonding applications – cold or hot press plywood gluing, high-frequency gluing, fortification of starch-dextrine adhesives, etc.

Urac 186 – Similar to Urac 180, but containing 60% resin solids.

Urac 185 – Craze-resistant urea-formaldehyde adhesive for assembly or secondary gluing operations. Two components – liquid resin and powdered hardener. Sets at room temperature with low pressure. Excellent for bonding decorative laminates, Masonite, and other hardboards.

Urac 110 – Similar to Urac 180, but in powder form containing no inert materials. Catalysts are available for general purpose wood gluing – cold or hot setting.

Urac 115 – Powdered urea resin modified to reduce clamping time in room temperature bonding of wood products without addition of highly acidic hardeners. Under special conditions, eliminates use of retaining clamps.

Melurac 300 – Melamine-urea-formaldehyde, one-package, fast-curing colorless powdered resin for hot pressing flat or molded plywood. Combines non-staining, moderate cure temperatures, durability, boil resistance. Ideal for exterior-grade plywood. New catalysts reduce cure rate to that of hot-press urea resins.

Melurac 301 – Powdered melamine-urea-formaldehyde resin without filler.

Melurac 255 – Powdered melamine-urea-formaldehyde resin, two-package, formulated solely as an adhesive for tapeless splicing of veneers.

Melurac 259 – Newly-developed, one-package melamine-urea-formaldehyde resin for tapeless splicing of veneers, requiring addition only of water.

Melamine 401—Hot press melamine-formaldehyde plywood adhesive for use with or without fillers. May be added to urea resins to improve durability of bond. Also used for laminating heavy timbers in marine applications and for general purpose work where a boil-resistant, non-staining bonding agent is required.

Melamine 405—A powdered melamine-formaldehyde resin formulated especially for the production of high-pressure, hot-setting laminates of glass cloth, asbestos, canvas, paper, or fine wood veneers.

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The trade-marks Urac, Melurac and Melmac are Reg. U.S. Patent Office

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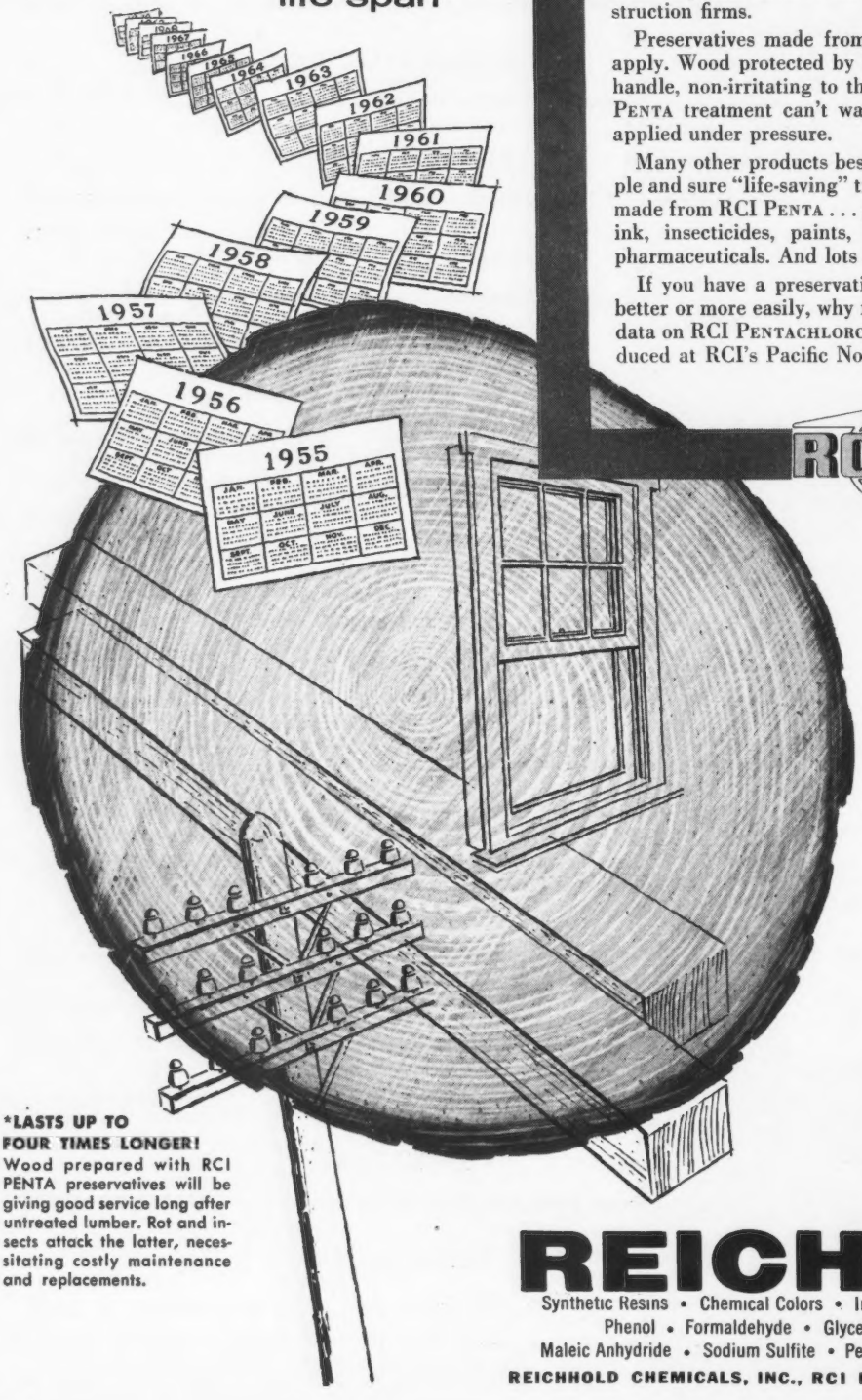
stretches lumber's life span*



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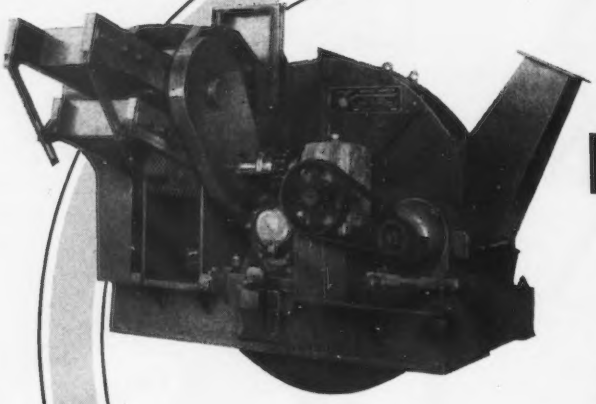
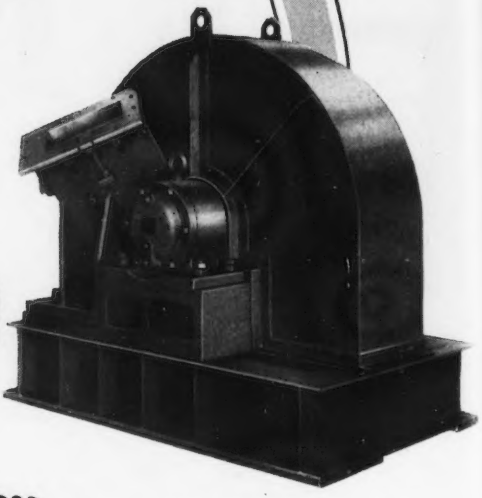
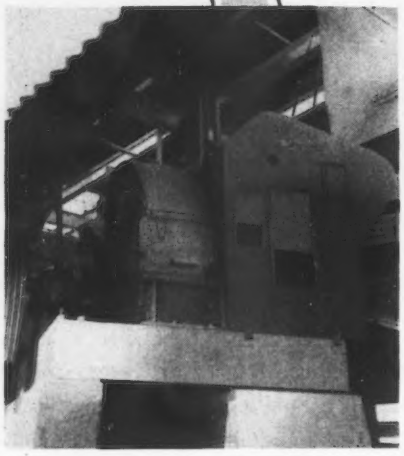


MECHANICAL FEED WASTEWOOD CHIPPER





HIGH SPEED — MULTI-KNIFE WASTEWOOD CHIPPER

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PRODUCE *Quality* CHIPS FROM SAWMILL WASTE

● SLABS ● EDGINGS ● ROUND WOOD OR VENEER CORES

MURCO 75" Mechanical Feed Wastewood Chipper installed in Allison Lumber Co., Bellamy, Alabama.

You too can start selling chips with MURCO Wastewood Chippers. You can produce from your sawmill waste, slabs, edgings, etc., the quality specification-size pulpwood chips that the industry demands. Illustrated are two MURCO Wastewood Chippers that are widely preferred because of their performance proved features of construction. Illustrated is the MURCO 75" Mechanical Feed Wastewood Chipper which when operated at 500 RPM and set to cut ⅜" to ¾" chips will produce approximately ten cords per hour . . . its newly designed mechanically operated spout for feeding sawmill wastewood into the disc knives at a controlled rate of speed assures utilization of all the wood yet holds slivers and odd sized chips to a minimum . . . either electric motor or Diesel engine drive . . . chipper can be equipped with chip blower housing for pneumatic chip conveying if desired.

MURCO High Speed Multi-Knife Wastewood Chippers are made in three sizes—56", 64", and 72" diameter discs and are today the most flexible, versatile chippers available to chip producers . . . operating with a minimum of slivers, sawdust and chip rejects . . . economically priced . . . easy to maintain . . . low maintenance cost. MURCO High Speed Multi-Knife Wastewood Chippers can be used as a portable unit, mounted on skids or trailer for Diesel engine drive.

Complete information is yours upon request.

FOR COMPLETE PROPOSAL. GIVE US THIS INFORMATION:

- **Species of wood to be chipped.**
- **Number of cords per hour.**
- **Dimensions of largest slab.**
- **Will chips be conveyed pneumatically.**
- **Type of drive desired Diesel or electric.**

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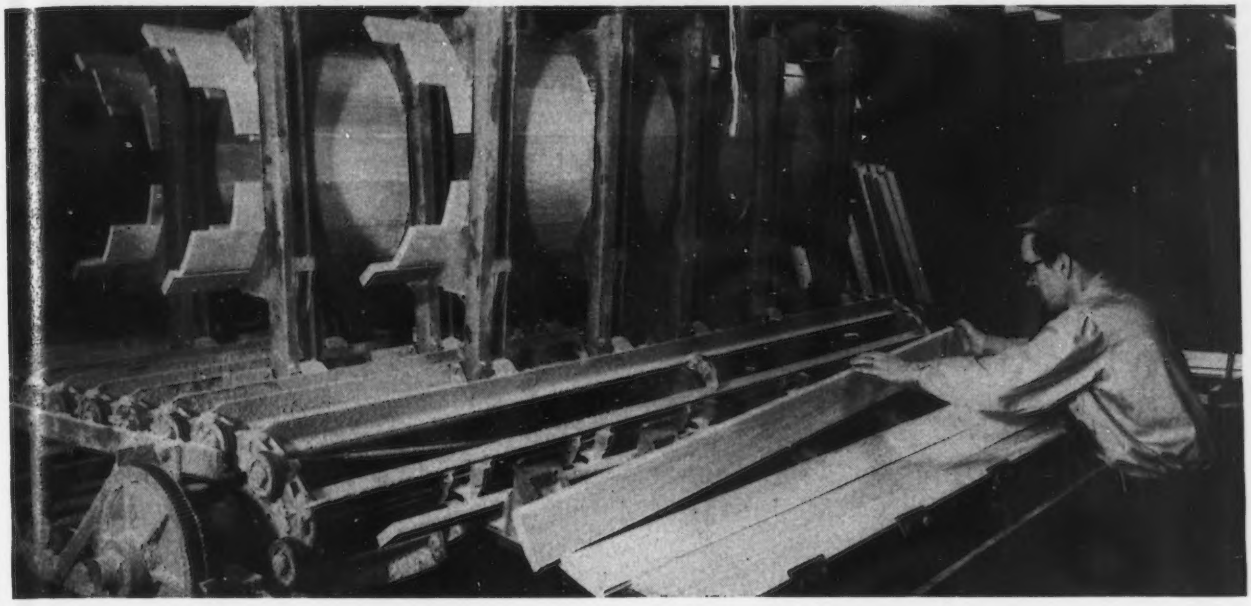
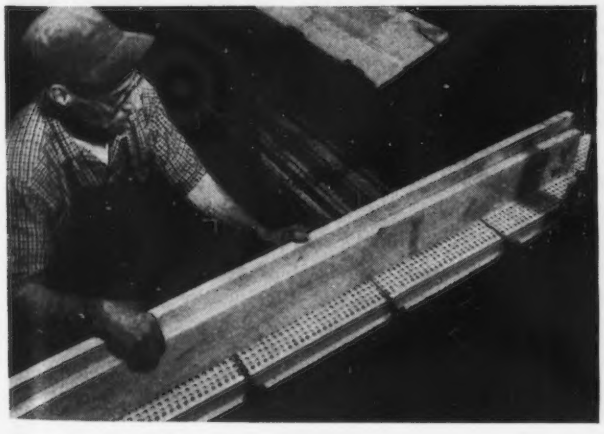


Flawless craftsmanship is traditional in the hardwood burial cases made by the New England Casket Company of East Boston, Massachusetts. Gluing is simplified with WOOD-LOK, National's cold run, ready-for-use resin glue. It helps create invisible glue lines, yet prevents chilled joints and speeds production.

WOOD-LOK prevents chilled joints

WOOD-LOK allows 5-7 minutes open assembly time, more than enough to avoid chilled joints in edge gluing extra long stock. Speed of set remains constant despite changes in humidity. Stock may be removed from clamp carrier after 30 to 45 minutes. No heating or mixing is necessary.

WOOD-LOK absorbs the impact of shaping blades with ease in this rugged turning operation. Films are neither brittle nor abrasive. Lathe knives need sharpening less frequently. Posts are built from a combination of willow, oak, birch and mahogany. Glue lines are imperceptible after turning.



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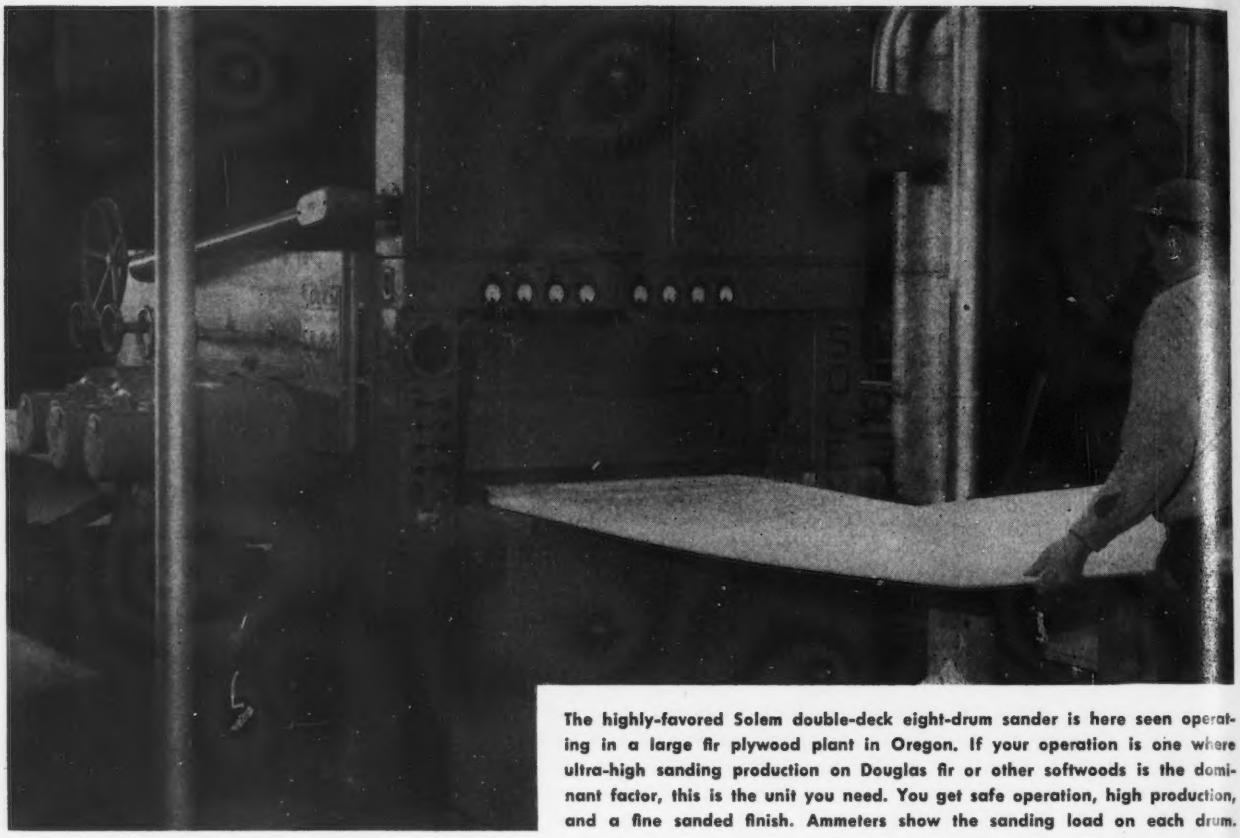
SPECIAL OFFER! Write for 5 gallons of WOOD-LOK and a complimentary glue applicator—on a trial and approval basis.

NATIONAL ADHESIVES. Woodworking Department WD (Resin Division), 270 Madison Ave., New York 16 • 3641 So. Washtenaw Ave., Chicago 32 • 735 Battery St., San Francisco 11 • 1511-23 So. Main St., High Point, N. C.



The highly-favored Solem double-deck eight-drum sander is here seen operating in a large fir plywood plant in Oregon. If your operation is one where ultra-high sanding production on Douglas fir or other softwoods is the dominant factor, this is the unit you need. You get safe operation, high production, and a fine sanded finish. Ammeters show the sanding load on each drum.

In A Drum Sander, You Want Only The Best Solem Is Superior At Every Point Of Use

Solem highly-competent endless-bed four-drum operating in the plant of Keller Manufacturing Company, furniture manufacturers in Corydon, Indiana. No other sander is suited for such a wide range of work, including the sanding of plywood with hardwood face veneers.

Plywood, furniture, millwork and other wood products manufacturers are sold on Solem sanders for many good reasons. High rate of sanding production obtained, the better sanded finish achieved, and extremely low maintenance cost involved are among the dominant factors. The eight-drum Solem is the prime favorite in double-decks, though Solem also builds a six-drum double for those who desire it. Similarly, the Solem four-drum has the greatest popularity among the endless-bed models, although three-drum and two-drum machines are also available. Any of these endless-bed units may be had in effective widths ranging from 31" to 85", in increments of six inches. Any one of these machines provides the greatest amount of solid sander satisfaction per dollar invested.

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☐ SE7–3—Three Drum	☐ SR8–6—Six Drum	
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UFORMITE JS-508 splicer glue gives wide assembly time

UFORMITE JS-508 is a one-component urea-formaldehyde resin adhesive which gives you wide latitude in assembly time in splicing veneers. Veneers spread with UFORMITE JS-508 may be spliced immediately, or they may be held for as long as three days before joining. This unique feature greatly simplifies glue room procedure, and avoids problems during weekend shutdowns.

UFORMITE JS-508 has other important advantages. When properly stored, it has a shelf life of up to one year. It disperses readily in water.

It has a pot life of 8 to 12 hours; a whole day's mix can be prepared at one time. UFORMITE JS-508 does not dust.

For a generous working sample of UFORMITE JS-508, write to department RG-1.

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Trailer courtesy Continental Trailer Co.

Presdwood stages 3½-ton holdup!

It's only two feet square. Yet, this small panel of Masonite Tempered Presdwood easily took the 3½-ton weight of a palatial 35-foot mobile home.

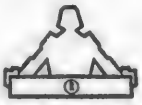
After four hours the trailer was lowered and the panel inspected. The Tempered Presdwood was as good as new.

What a dramatic demonstration of the enduring strength inherent in Presdwood! This grainless, man-made material is stronger in many ways than the wood from which it comes.

Thousands of firms now profit by Presdwood's outstanding strength, as well as its low cost, high dimensional stability, ease of fabrication and of surface finishing. We invite you to discover how Presdwood®—in any of its 44 types and thicknesses—can smooth production and improve the things you make. Write Masonite® Corporation, Dept. FPJ-12, Box 777, Chicago 90, Ill.

Continental Trailer Co. uses Presdwood *in* trailers because of its strength and resistance to road shock

Marine manufacturers, too, call on Presdwood. I Chris-Craft boats it adds style and stability.

Look for this man  He makes the difference

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what's glue* got to do with the music she makes?

A manufacturer of fine musical instruments really appreciates the importance of glue to the life and performance of his product. Guitars, mandolins and ukuleles made by The Harmony Company, Chicago, are the finest by every standard. They represent six decades (more than 63 years) of ever increasing leadership in their field. Harmony has won this leadership by maintaining peerless standards of quality and workmanship... by alertness to modern production techniques... and tireless research to determine improved methods to make possible better musical instruments at popular prices.

***Patented* Glue Formula gives Harmony an Advantage**

National Casein's patented FA 300 gap-filling, non-craze urea resin glue plays an important part in the manufacture of the Harmony Company's fine fretted instruments. Where close tolerances are to be glued and radiuses are to be considered on high frequency or resistance heating jobs, National Casein's FA 300 will mean the difference between a satisfactory bond and a reject — between purity of tone and distortion. Where joint strength and durability are requisites, under heavy stress or maximum vibration, as with stringed musical instruments, National Casein's FA 300 meets a very great need.

Write for Technical Data Folder FA 300. Address the National Casein office nearest you.

Here, by an ingenious combination of resistance heating, pneumatic pressure and the right glue, Harmony speeds guitar body assembly. Harmony reduces the body assembly cycle by hours.

One of Harmony's modern heat and pressure rib gluing assembly units. In the background, an antiquated hand assembly wheel.

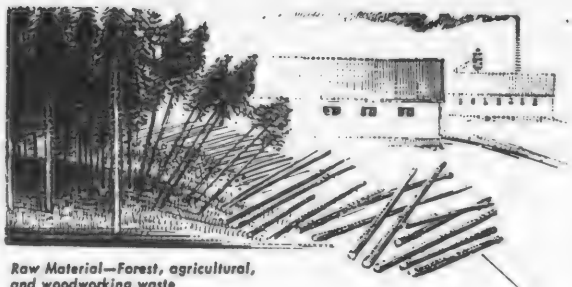
Flanked by frames, tops and backs, another Harmony guitar body goes into an assembly press for FA 300 glue curing.

National Casein*

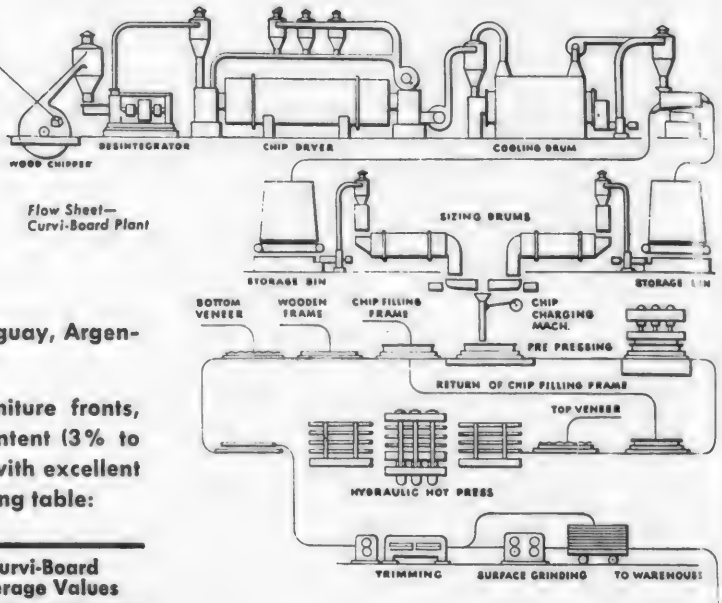
601 West 80th Street, Chicago 20, Illinois

Broad and Fulton Streets, Riverton, New Jersey

THE CURVI-BOARD PROCESS



Raw Material—Forest, agricultural, and woodworking waste



Flow Sheet—Curvi-Board Plant

Although new in the United States, the Curvi-Board process, developed by Paul Harder, Liechtenstein, is patented in 33 countries, and plants are either in operation or under construction in Canada, Holland, France, Switzerland, Italy, Sweden, Uruguay, Argentina, Colombia, Greece, Spain and Portugal.

Particle board, core stock, semi-fabricated furniture fronts, complete panels and doors are low in resin content (3% to 6%), low in density (about the same as spruce) with excellent strength and workability, as shown in the following table:

Tests	Curvi-Board Average Values
Density	0.48 — 0.60
Compression resistance, across, p.s.i.	1320 — 1780
Compression resistance, lengthwise, p.s.i.	19250
Bending strength, lengthwise, p.s.i.	3160
Bending strength, across, p.s.i.	2820
Nail withdrawal test, lbs.	53 — 64
Screw withdrawal test, lbs.	187 — 242
Thermal conductivity, kcal/m x h x c	0.07

Test values obtained by the Institute for Testing of Materials in Zurich. Material: Curvi-Board panel, 19 mm thick. Resin content: 3%, oven dry weight. Two layers of 1 mm veneer on each side, cross-grained.

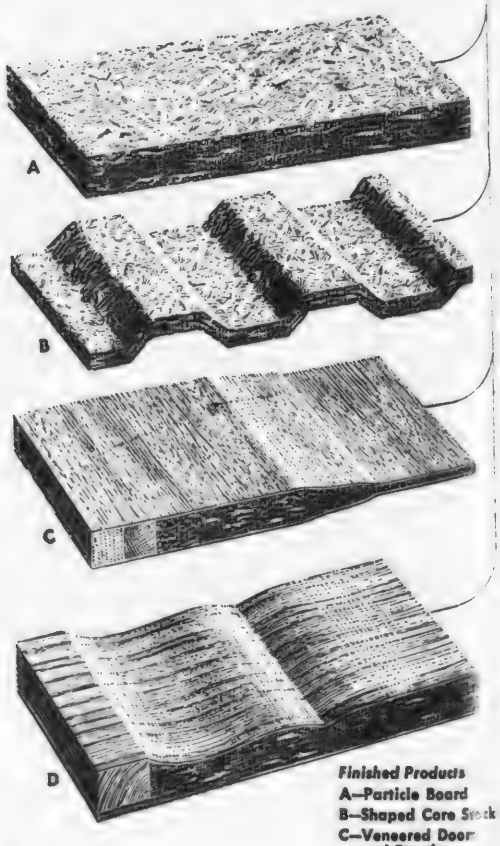
In the Curvi-Board method, the binding resin is cured in a press heated both by hot water and by high frequency. A complete door may be produced in one operation including frame wood, core, cross and face veneers. Molded furniture parts may also be made in one operation.

Curvi-Board is manufactured as a one-layer or three-layer board. The one-layer board is used principally in doors and building elements, and the three-layer board in furniture making.

Building elements are structurally self-supporting and may be formed to size for special purposes. Thickness may be varied from ¼" up to 4¾"; length and width as dictated by market demands.

A Curvi-Board plant with a capacity of 15,000 tons per year can produce approximately 400,000 doors or 15,000,000 square feet of ¾" board. Plants may be larger or smaller.

Curvi-Board plants are planned and designed by A B Defibrator, Stockholm, Sweden. Inquiries originating in U. S. A. should be addressed to American Defibrator, Inc., 405 Lexington Avenue, New York 17, N. Y.



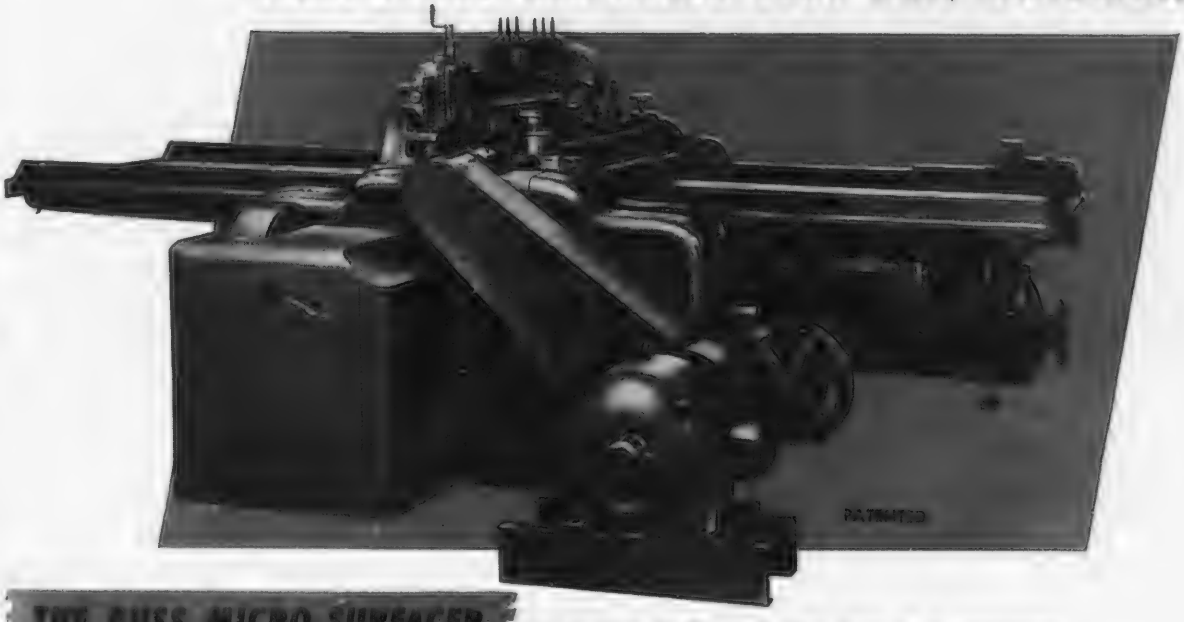
Finished Products
A—Particle Board
B—Shaped Core Stock
C—Veneered Door and Panels
D—Veneered Furniture Parts

DEFIBRATOR

BUSS

The MICRO-SURFACER

A HIGH PRODUCTION MACHINE for PLANING HARDBOARD and OTHER VERY THIN MATERIALS!



THE BUSS MICRO-SURFACER was developed to do what no other planer will do satisfactorily — to plane the very thin, highly flexible materials such as certain types of hardboard, presswood and related materials, rapidly and accurately. Close tolerances are easily maintained on this machine by means of a patented work platen which rigidly holds down the stock during the feeding and cutting operation. It employs our standard planer cutterhead with high speed steel knives operating at speeds up to 5,000 RPM. (Carboloy knives are available for applications involving abrasive materials). The MICRO-SURFACER can be furnished with in-feed and out-feed conveyors for rapid handling of stock and incorporates such exclusive BUSS features as: Chrome-plated wearing surfaces, semi-automatic control of lower rolls and pressure bar, one-shot lubrication, etc. Available in various width capacities up to 50".

The services of our engineering staff are available for consultation and working out details of all planer applications. Complete cooperation will be extended in any prospective application such as profile and contour work. Drop us a line.

BUSS
MACHINE WORKS
SINCE 1862

PLANER SPECIALISTS

Now Pennsylvania Furniture Co. bends and laminates fine veneer serpentine fronts in a fraction of the former time with THERMATRON

The old method of gluing in a cold press used to require almost three hours, but the THERMATRON high frequency installation in Pennsylvania Furniture Co.'s York, Pa. plant has created a revolution! Using the 15 KW output THERMATRON generator and 225 ton plywood forming press illustrated, as many as several layups of six to ten pieces of veneer are precision bent and laminated at once over their inexpensive hardwood moulds . . . And the time cycle is no more than 2¾ *minutes*. Other than loading, it's a push-button operation throughout, with no special skills required.

We'd like to survey *your* present operation. We can prove that THERMATRON high frequency equipment will do a superior job while it slashes away at costs. Frees large drying areas for more profitable purposes, too. Write or phone us now without obligation — And ask for our latest bulletin #FP-8.

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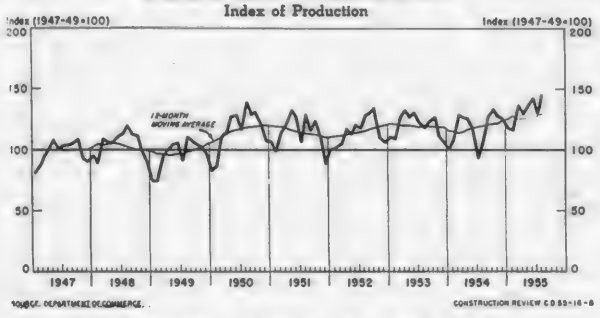
FPRS NEWS-DIGEST

Volume 5 DECEMBER, 1955 Number 11

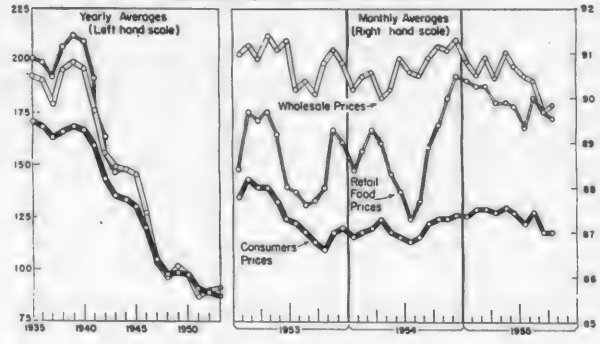
GRAPHIC TRENDS

Lumber and Wood Products
Index of Production

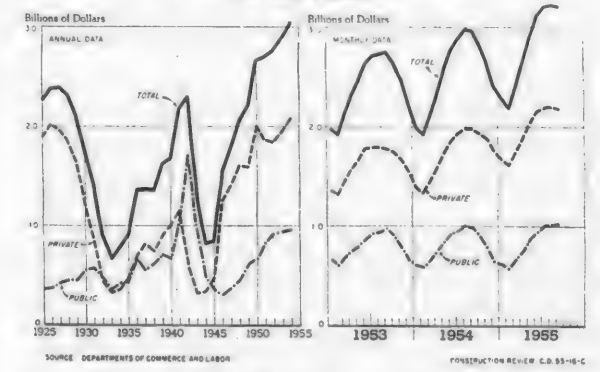


SOURCE: DEPARTMENT OF COMMERCE. CONSTRUCTION REVIEW C.D.55-16-B

PURCHASING POWER OF THE DOLLAR
As measured by Wholesale Prices, Consumers' Prices, and Retail Food Prices
Source: U.S. Dept. of Commerce. 1947-49=100



New Construction Put in Place
(In 1947-49 Prices)



SOURCE: DEPARTMENTS OF COMMERCE AND LABOR CONSTRUCTION REVIEW C.D. 55-16-C

13-TO-1 RETURN from research expenditures in past 25 years was estimated by Philco Corp., which said total U. S. research costs in that period amounted to $30 billion.

—Industrial Research Newsletter

BUSINESS OUTLOOK

U. S. LUMBER PRODUCTION first ten months of '55 was estimated 33.1 billion board feet, or 8.6 per cent greater than corresponding period last year. Softwood production was up 10.8 per cent, hardwood production equalled last year's.

—NLMA

ALL-TIME RECORD is in sight for furniture industry in '55. Wood household furniture manufacturers booked more orders in October than in any other October in their history, Seidman & Seidman report. Totals for first 10 months this year indicate 21 per cent more new orders than in same period of '54.

—The Wood-Worker

U. S. ECONOMY will remain on high level in '56 in opinion of leading labor economists. They look for continued increases in production levels during first six months next year, gentle tapering down becoming apparent in last half. Members of American Bankers Assn. agree that '56 will be good business year, but generally don't expect it to match this year's performance.

—Veneer Newsletter

PEAK CONSTRUCTION YEAR is foreseen for 1956, with new construction expenditures expected to reach $44 billion, or 5 per cent above $42 billion indicated for 1955. A slight rise in private outlays will come from gains in non-residential building. A continuing trend toward larger houses with more quality features means that '56 dollar outlays will not drop as much as housing starts, estimated at 1.2 million next year compared to 1.3 million in '55.

—U. S. Dept. of Commerce

SOCIETY NEWS

Inland Empire Section Plans January Meeting in Spokane

High-speed wood lamination will be among technical subjects discussed at the winter meeting of the Inland Empire Section in January at the Davenport Hotel, Spokane, Wash. George G. Marra, Head, Wood Technology Section, State College of Washington, Pullman, will speak on "Development of a Method for Rapid Laminating of Lumber without the Use of High-Frequency Heat."

Cameron J. Warren, Section Chairman, will preside at the Spokane meeting. Other papers being considered for the program include: pulping, composition boards, prefabricated houses, building codes and insurance problems, and electronic sorting of bark from fiber.

Eastern Canadian Section To Make Four Student Awards

Plans are being completed for the Annual Meeting of the Eastern Canadian Section of FPRS, to be held March 1 and 2, 1956, at the Royal York Hotel, Toronto. Chairman Peter M. Morley, Canadian International Paper Co., will preside at the two-day technical sessions.

FPRS lapel pins will be presented by the Section to all members attending the Annual Meeting, it was announced following a recent Executive Committee meeting.

A highlight of the meeting will be presentation of four annual awards to undergraduate students in forestry, engineering, and/or architecture for the best technical papers in the forest products field. Two first prizes of $50 each and two second prizes of $25 each will be given for the winning papers. The papers may be part of individual course requirements or may be written specially for this competition.

Northeast Section Meeting Scheduled in Springfield

"Synthetic Wood Products" will be the theme of the Northeast Section Spring Meeting to be held in Springfield, Mass. Section Chairman Charles R. Lockard will preside at the meeting, scheduled April 19–20, 1956.

New Rules Announced for 1956 Wood Award Contest

The Wood and Wood Products Award, sponsored by the Vance Publishing Company, Chicago, will again be offered this year to the two students making the most significant contributions to forest products industry technology. The 1956 awards will

(Continued on page 72–A)

"Look Ahead" Theme Predominant at FPRS Region, Section Meetings

Eleven of FPRS' 13 Sections attracted some 1,000 persons to meetings this past fall. Two others, Inland Empire and Eastern Canadian, have meetings coming up this winter, giving the Sections' 100% participation for the season. More than 100 authors, moderators and program chairmen combined their efforts to stimulate thought and action on today's complex problems of wood technology and distribution.

Subjects ranged from everyday production improvement techniques to long-range thinking on new products and markets as far ahead as 1975. No doubt the phenomenal recovery in business conditions within certain segments of our own industry in the past year, and the realization, statistically confirmed, of spiralling economic necessities for a population expected to reach 212 million by 1975, have stimulated FPRS program planning this fall. Several meetings emphasized this "Look Ahead" theme.

North–Central Region Meeting, Nov. 15–17

Perhaps the outstanding session of this type, drawing some 250 persons, was that on "Implications of the Stanford Research Institute–Weyerhaeuser Timber Company Report, America's Demand for Wood, 1929–1975," held in Chicago.

IMPORTANT FPRS DATES

Feb. 1956: Pacific Northwest Section Meeting, Longview, Wash.

March 1–2, 1956: Eastern Canadian Section Annual Meeting, Toronto, Ontario

Spring 1956: Mid-South Section plant tour to Kirby Co., Lufkin, Texas

April 19–20, 1956: Northeast Section Meeting, Springfield, Mass.

June 4–7, 1956: FPRS Tenth National Meeting, Asheville, N. C.

Fall, 1956: Mid-South Section Annual Meeting, Laurel, Mississippi

Fall, 1956: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

G. W. Stanley, Jr.

The first region-wide meeting in FPRS history, combining meetings of three Sections, Midwest, Great Lakes, and Upper Mississippi, was conceived by National Executive Board Member Robert L. Hiller, to fill the need of a large scale meeting when local members cannot travel long distances to National Meetings. The exceptionally high caliber program was arranged by George W. Stanley, Jr., cooperating with the ASME Wood Industries Division. A unique value of this meeting was the ability to attract a number of top executives of the wood industry as speakers because of the larger regional scope.

The Stanford Study panel was moderated by Dr. Frank H. Kaufert, Director of the School of Forestry, U. of Minnesota, and FPRS National Vice-President.

William E. Hunt, Executive Vice-President, U. S. Plywood Corp., summed up the growth and outlook for the softwood plywood industry as follows: "The Stanford Report predicts plywood production on a 3/8" basis to go from 3, 300,000,000 sq. ft. in 1952 to 4.6 billion in 1960 and 5.5 billion in 1965. We feel the report is conservative for already in 1955 production will run 5 billion feet and in 1956 an estimated 5.2 to 5.5 billion feet. Thus, this industry should attain the predicted 1965 figure in 1956."

Paul B. Shoemaker, Vice-President, Sales, Masonite Corp., said, "The Stanford Report is not overstated. As we see it, it takes a middle-of-the-road trend for the next ten years. For example, the 1960 estimate for hardboard production is 1.6 billion feet on a 1/8" basis. I am proud to say that in 1955 shipments for our industry have already reached 1.583 billion sq ft. and an established productive capacity of 3.7 billion feet. In other words, the hardboard industry today stands five years ahead of predictions."

Joseph G. Griswold, Jr., General Manager, The Widdicomb Company, Grand Rapids, Mich., quoting from well-known economist-researcher, Arno H. Johnson of J. Walter Thompson Co., predicted furniture shipments to double in the next 20 years, rising from the current $2½ billion to ap

(Continued on page 20–A)

FPRS First Regional Meeting Attracts 250 Registrants

INSCRIBED PLAQUE was presented to Weyerhaeuser Timber Co. for making Stanford Report on "America's Demand for Wood—1929–1975" available to wood industry. Plaque was presented at North-Central Regional Meeting by FPRS President Moss B. Christian (center) and accepted by B. J. Orell, vice-president of Weyerhaeuser Sales Co., St. Paul. Looking on are Wayne C. Lewis, Past Chairman of Midwest Section; President-Elect Ralph H. Bescher; and Vice-President Frank H. Kaufert.

WOOD COMPOSITION BOARD COMMITTEE members met during North-Central Meeting to plan committee's technical session scheduled for Tenth National Meeting in Asheville, N. C. Left to right are: Wayne C. Lewis, U. S. Forest Products Lab; A. L. Mottet, Long–Bell Lumber Co.; Chairman George G. Marra, Washington State Institute of Technology; J. B. Palmer, Masonite Corp.; J. R. Roberts, Weyerhaeuser Timber Co.; R. H. Sides, Miller–Hofft, Inc.; and James d'A. Clark, Consulting Engineer.

STANFORD REPORT DISCUSSION highlighted North-Central Regional Meeting. Participating were, left to right: E. C. Swanson, Vice-President, Andersen Millwork Co.; P. B. Shoemaker, Vice-President, Sales, Masonite Corp.; J. G. Griswold, Jr., General Manager, The Widdicomb Co.; W. E. Hunt, Vice-President, Sales, U. S. Plywood Corp.; moderator, Dr. F. H. Kaufert, FPRS Vice-President; Robert Kolbe, Chief Forester, Connor Land and Lumber Co.; recorder, F. J. Rovsek, FPRS Executive Secretary.

COMPOSITION BOARD SESSION speakers at North-Central meeting included: L. R. Louis, vice-president, Bramco, Inc.; Don Collins, Adamson United Co.; and L. A. Patronsky, Wabash Screen Door Co.

REGIONAL MEETING COMMITTEE members are shown with two secretaries who handled registration. Seated are the secretaries to Joe Allegretti and Bill Kluender. Committee included: Joe Allegretti, Arrangements Chairman; Fred Loveland, Chairman of Wood By-Products Session; Bill Kluender (seated), Finance Chairman; and Bob Hiller, General Chairman.

FURNITURE PLANT ECONOMY was discussion topic during the North-Central Meeting. Panelists were, left to right: Frank DeYoung, R-Way Furniture Co.; moderator, James F. Hamilton, Michigan College of Mining and Technology; Wayne Hutchins, American Seating Co.; Serge A. Birn, Serge A. Birn Co.; and E. Sigurd Johnson, N. C. State College.

EFFICIENT USE OF MATERIALS was discussed during furniture manufacturing session by, left to right: J. F. McCaslin, DeVilbiss Co.; R. H. Bennett, Jr., Stow and Davis Furniture Co.; Chairman Stephen B. Preston, U. of Michigan; and A. E. Wylie, State U. of New York College of Forestry.

OFFICIAL LUNCHEON at Chicago meeting was attended by more than 250 persons. Above photo of luncheon group includes: Dwight W. Bensend, Iowa State College; Gardner A. Garlick, Protection Products Manufacturing Co.; E. L. Patton and Forrest Beil, Curtis Co., Inc.

Section Meeting Speakers Look at Wood Industry's Future

NORTHEAST SECTION LUNCHEON speakers included FPRS President Moss B. Christian, left; President-Elect Ralph H. Bescher, second from right; and C. G. Fick of General Electric Co., far right. Seated are: Bescher; Charles R. Lockard, Northeast Section Chairman; Edward G. Locke of U. S. Forest Products Laboratory, past president of FPRS; and Frank T. Parrish of Heywood–Wakefield Corp., Northeast Regional Member of Executive Board.

FUTURE WOOD PROCESSES were discussion topic during Northeast Section Meeting. Participants included, left to right: Rudolph Willard, North Carolina State College; Joseph R. Wilner, Wilner Wood Products Co.; Joseph Coufal, National Adhesives; Fred C. Simmons, Northeastern Forest Experiment Station, and Chairman, Chester L. Babcock, Babcock Machinery Co.

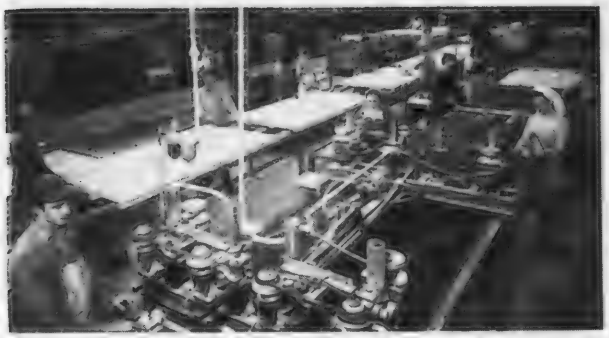
NORTHEAST SECTION OFFICERS attending meeting were, left to right: Chester L. Babcock, Trustee; Charles R. Lockard, Chairman; Donald Pierce, Trustee; William Delmhorst, Secretary-Treasurer; Newell A. Norton, Trustee; Eric A. Anderson, Trustee; Don Saunders, Vice-Chairman; Paul Graham, Membership Chairman; Jack Batson, Trustee; and Frank T. Parrish, Northeast Regional Executive Board Member.

PREPARING FOR ATOMIC AGE was session topic during New York meeting. Speakers included, left to right: Richard F. West, Noel Symons, Wilfred A. Cote, Paul Graham, Dr. Charles R. Williams, and moderator, Robert C. Fraunberger.

WASTE PREVENTION & UTILIZATION was topic at Idea Exchange Session led by J. Allan Hauter. Participants included Newell A. Norton, Fred C. Simmons, and Raymond J. Hoyle.

GLUING IDEA EXCHANGE session at Northeast Meeting, left, was led by J. W. Maxwell, Borden Co. Prof. J. Harry Rich led discussion of wood moisture control (second photo from left). Another "Idea Exchange" session was held to discuss wood finishing developments.

OHIO VALLEY SECTION meeting participants, left, were: Carl A. Seng, Robert Allen, Russell W. Green, Carl Trinkle, Richard Elliott, and C. M. Kreider. Stanford Report panelists, right, were: George R. Walters, C. M. Kreider, Moderator C. D. Dosker, R. M. Foot, and Ed Dulaney.



PREFABRICATED HOUSES being manufactured at U. S. Steel Homes plant, New Albany, Ind., were viewed by Ohio Valley Section Meeting attendees. W. J. Messingschlager, Head of Product Service, was in charge of tour arrangements.

MID-SOUTH SECTION MEETING participants included: James R. Welsh, Section Chairman W. J. Tomford, representative of Soderhamn Machine Mfg. Co., J. Copeland, and Mark M. Lehrbas, session moderator.

NEW OFFICERS of Mid-South Section, elected at Memphis meeting, were congratulated by FPRS President Moss B. Christian, right center. They include: D. M. Fisher, Vice-Chairman, left center; Mark M. Lehrbas, Trustee; Dick Burkhart, Program Chairman; John Wells, Secretary-Treasurer. Looking on are Trustees Dick Wilson, John Fox, and Al Pakula.

MEMPHIS MEETING participants included, left to right: Paul R. Kramer, Texas Forest Service; Charles Latimer, Tours Chairman; James L. Love, Trustee; W. Jeter Eason, Regional Executive Board Member; W. J. Tomford, retiring Chairman; Virgil Cothren, Finance and Registration Chairman; and Dick Burkhart, Program Chairman.

NEW STUDENT MEMBERS from Oklahoma A & M College, left front, were among those attending Mid-South Section Meeting. FPRS President Moss B. Christian, luncheon speaker, is at center front.

FLORIDA–GEORGIA–ALABAMA Section participants (left photo), were, F. H. Owles, Jr., Past Chairman D. B. Richards, W. B. Clements, Program Chairman J. A. Vaughan, and Carl Brice. Attendees included (right photo): Ray Osborne and C. Miles Burpee, American Wood Preservers Institute; Amos W. Kelley, Wood Treating Chemicals Co.; John Reno, Pacific Lumber Co.; and Ira Hatfield, Monsanto Chemical Co.

SECTION ACTION PROGRAM was among topics discussed at second F–G–A technical session. Panelists and session speakers included (left photo): W. T. Neal, Jr., O. W. Boehm, T. E. Brassell, Frank Parker, and W. C. Hammerle. Center photo shows new F–G–A Section officers: seated, E. M. Conway, Vice-Chairman; and L. R. Rand, Secretary-Treasurer; standing: J. B. Huffman, Chairman; D. B. Richards, Past Chairman; and Carl Brice, Trustee. Kiln Drying Assoc. in Florida, Georgia, and Alabama was organized in conjunction with F–G–A Section meeting. Right photo shows organizing committee: W. R. Smith, Chairman L. F. Rand, W. K. Loughborough, Otto C. Heyer, E. M. Pope, Secretary J. B. Huffman, and R. C. Rietz.

FPRS News-Digest, Continued

Regional Meeting

(Continued from page 16–A)

proximately a $5 billion level in 1975. As for trends, he reports, "I look for continued shipment of large quantities of furniture, uncrated, cartoned or wrapped rather than crated. The use of metals and plastics will undoubtedly continue to grow. Use of hardboard and chipcore will continue to grow and reduce the amount of solid lumber as such in wood furniture. We look for hardwood plywood to expand since it plays four times the role of softwood in furniture."

Alert to New Trends

Earl C. Swanson, Vice-President, Andersen Co., Bayport, Minn., speaking for the sash, door and millwork segment said, "The Report is largely a projection rather than a prediction of things to come and should be objectively interpreted. I firmly believe that coming events can be changed by planning and thinking ahead. As far as our industry is concerned, we went through an era of rapid expansion a generation or two ago. And while the report projects a future decline in the amount of lumber used for millwork per house unit, at the same time it projects a sufficient increase in the number of housing units so that the net is an increase in the production level of millwork. The millwork industry is alert to new trends. Examples are: ready-hung doors are coming into their own with a real future; window units are now sold and installed as complete units including weatherstripping, hardware, etc. Finally, I would like to emphasize the role of the American salesman in our future . . . we cannot possibly weigh the tremendous influence which he has within his power to exert on our future."

Dr. Frank H. Kaufert, emphasizing the research aspect, said, "Of all wood industries, pulp and paper invests the greatest percentage of its total sales in research, and as we all know, is the most progressive segment of the industry. The plywood industry spends somewhat less than pulp and paper, yet here again its tremendous progress indicates how research pays off. Lumber invests the lowest percentage and has suffered loss of markets in consequence. We should recognize at the same time the vulnerability of the lumber industry which, compared with more concentrated industries, is made up of many small production units difficult to tab for research investment."

Weyerhaeuser Timber Co. Cited

A highlight of the Chicago meeting was the presentation, in behalf of FPRS' 3,000 members throughout the United States and Canada, of an honorary inscribed, bronze plaque to the Weyerhaeuser Timber Company for their generosity in underwriting and making available for the benefit of the entire wood utilizing industries the now famed Stanford Research Institute Report, "America's Demand for Wood, 1929–1975". The plaque was presented by Moss B. Christian, National President of FPRS, and accepted by Bernard Orell, Vice-President, Weyerhaeuser Sales Company, St. Paul, Minnesota.

Chipcore Discussed

Also in Chicago, chipcore—the "hottest" subject in the wood industries today, commanded the attention of more than 100 persons gathered jointly by the American Society of Mechanical Engineers Wood Industries Division and FPRS.

More Society and Industry News pages 70-A–79-A

L. R. Louis, Vice-President of Bramco, Inc., New York, described progress of the Bartrev Press, the first machine for the production of chipboard by continuous process. The machine is 155′ long, weighs 200 tons, and has an annual production of 20 to 53 million sq. ft. of board. It produces boards in the density range of 0.50 to 0.80—in thicknesses of ¼″ to ¾″, and is said to cost $750,000.

R. D. Bibby, until recently General Manager of Lane Cedar Chest Co., described the new "Lanewood" process, estimating annual costs to produce 800–1000 feet per hour of ¾″ chipcore as follows: multiplaten press, $325,000; vertical extrusion, $180,000; Lanewood, $140,000. Who can afford a particle board plant? Bibby's answer —any company with a regular supply of wood waste in excess of 40 tons per week.

Northeast Section, Oct. 20–21

In New York, 150 Eastern industry leaders gathered to discuss, "Wood in the Atomic Age", again emphasizing the shape of things to come. As to furniture of the future, Rudolph Willard said, "We need to get away from thinking purely in terms of making furniture parts out of lumber; and need to keep up with established, advanced techniques in working metals and plastics. Future cores may be largely manufactured of air, of the honey-comb, sandwich panel variety. The industry will go more and more to knock-down and semi-knock-down construction in an effort to reduce transportation costs.

Robert Solow, Keller Products Co., Manchester, N. H., speaking on "Laminates in Building, 1975," predicted a merger between laminates and prefabrication, a move destined to establish a completely new building industry. He foresees "package homes" unexcelled in design and quality and within the price range of the vast medium income group. The existing method of building, "one board, one nail at a time," will go by the way. "Sandwich panels" or laminates can help in two major degrees. Initially, they lend themselves to the creation of a complete building module, which is structurally independent, fully insulated, factory prefinished, and ready for rapid installation. Secondly, by virtue of the I-beam like construction, they are capable of carrying large loads and spanning greater distances without intermediate supports.

Joseph R. Wilner, Wilner Wood Products Co., Norway, Maine, owners of numerous debarking operations in a radius of sawmill operations, and using their own premises as a concentration yard for chipping, had this to say about the future of wood utilization. "We are getting 100% utilization of the logs which are landed in our yard. We have over a period of years been using round-edge white pine lumber, weighing one ton per 1,000 board feet kiln dried. After getting our primary product, wedgie heels, out of the lumber, we are still able to ship over one ton of finished wood flour for every 1,000 board feet of lumber used. As fuel, one pound of groundwood, to 20 mesh, burned in suspension in the average boiler under slight air pressure, will favorably compete with one pound of Bunker C oil or coal as far as BTU's are concerned." He added, "One of the key areas of development for waste in the future will be home building. The next 25 years will see parts of homes—floors, walls, roofs ceilings—built out of waste and binders. Paraphrasing a well-known slogan, 'We can truthfully look forward to a better way of life through wood utilization.' "

Paul H. Graham, Clinic of Wood, emphasizing research facilities for the small forest products industry, noted that "The management of America's successful firms spend 5% of the time dealing with current problems and

(Continued on page 70–A)

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What's the Latest Progress on the New FPRS Office Building?

DURING MY TRAVELS to Society meetings this past fall in New York, Chicago, and Memphis, many of our Section officers and individual members have asked me, "What's the latest progress on the new FPRS office building in Madison?" Since the question seems somewhat universal, I feel that now is a good opportunity to bring all of our 3,000 members a brief progress report, and at the same time acknowledge long-overdue credit to certain helpful organizations and people.

M. B. Christian

As of today, we do not have any definite date set for the actual construction of the building. A good guess is that it could be in the spring of 1957, or later, depending wholly upon our ability to underwrite the project.

Present Financial Status

Financially, here's how we stand. We own outright a choice lot which, along with our architectural plans and certain improvements, represents an investment of $12,500. The exact location is adjacent to University Avenue, Madison, Wis., in an area of university and government research laboratories on the fringe of the University of Wisconsin, about one block from the U. S. Forest Products Laboratory. In addition, we have a balance of "building fund cash donations" of approximately $1,000, and an accumulated reserve of $5,000 in Building and Loan stock. Thus, we are about $18,500 along the way toward an ultimate investment of some $65,000. Here is how we arrive at that figure. The building itself we estimate will cost about $50,000, of which $15,000 may be in the form of donated materials. Several thousand dollars more may be donated as furnishings. The actual construction, then, will cost the Society about $35,000 in cash, a portion of which will undoubtedly require a mortgage loan. So you can see that we still have a considerable distance to go to achieve our goal.

At this time, I would like to acknowlege those firms who have offered to contribute materials toward the building. They include: Aberdeen Plywood Corp., Arkansas Oak Flooring Co., The Borden Co., Coats, Huddleston & Buck, Curtis Companies, Inc., Darlington Plywood Co., Elliott Bay Mill Co., Fiberesin Plastics Co., J. J. Fitzpatrick Lbr. Co., Gamble Brothers, Harbor Plywood Corp. of Oregon, Hardwood Corp. of America, Jasper Chair Co., Knight Mfg. & Lbr. Co., Ltd., Koppers Co., Inc., M & M Wood Working Co., Masonite Corp., The Mengel Co., Oval Wood Dish Corp., Pacific Lumber Co., Paine Lumber Co., Ltd., Precision Panels, Inc., Southern Plywoods, Inc., Chester B. Stem, Inc., Thomason Plywood Corp., Unit Structures, Inc., U. S. Plywood Corp., Vancouver Plywood Co., and Wells Furniture Mfg. Co. To these companies the Society and its Executive Board extend their most heartfelt gratitude.

Materials Contributed

From all indications, we are already reasonably well oversubscribed on all the contributed wood materials which will be needed. Our biggest job now is to raise the necessary cash. It is most gratifying to acknowledge some of the cash donations which have been made to date: FPRS Midwest Section, $1,000 plus an additional $500 pledge made recently, The Crossett Company, $300, Edward Hines Lumber Co., $250, Soderhamn Machine Mfg. Co., $50, Drake Saw Co., $50 and J. E. Gurvitch Lumber Co., $25.

To plan the building and obtain the necessary materials and funds to date has required a great deal of effort on the part of various committees. The Executive Office Building Finance Committee is headed by our President-elect, Ralph H. Bescher, assisted by L. J. Carr and Ray Berry. Building architecture is the responsibility of W. Jeter Eason with the supervisory assistance of architect Otto Heyer, Madison.

It has been a pleasure to give you this brief progress report. And, while we have encountered minor delays from our original planning, of this much you can be certain—your Executive Board and all persons connected with this project are making every effort to see to it that when finally erected, this building will be a tribute to the 3,000 members and companies represented in our Society. Your Executive Board or members of its committees will welcome any thoughts or suggestions you may care to submit.

Wishing you a most prosperous New Year.

MOSS B. CHRISTIAN, *President*

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The Future of the Wood Furniture Industry[1]

CLYNE CRAWFORD

President, Crawford Furniture Manufacturing Corp., Jamestown, New York; Past President and Director, National Association of Furniture Manufacturers

LOOKING AHEAD and forecasting the furniture industry's future is important from a managerial standpoint in long range planning. Here is what I think the next ten years will bring in sales, in technical progress, and in cost savings. Each of these developments is largely dependent upon the other two. Certainly sales is dependent upon production efficiency, and all progress in factory operations and research is supported by the sales dollar.

We are apparently free from a shooting war in the near future and are back to a competitive sales situation. Going back to "normal" is a situation which many people today have never experienced or forgot with the boom of the forties caused by the war. This highly competitive period will create great progress, yet it will develop many casualties.

The tremendous growth in our economy is becoming accelerated with each increase in disposable net income (income after taxes). Disposable net income to individuals will probably increase by 20 per cent in 1960 over 1955 and 33 per cent by 1965 over 1955. The share of the increase the furniture manufacturers obtain depends upon many factors. The real test of furniture sales is its comparable value to other products competing for the income dollar and the ability of the industry to awake a sleeping giant called obsolescence.

This year the furniture manufacturers will end the year with an increase in shipments of 15 per cent over 1954 and about 7 per cent over 1953 for an all-time record. It is my feeling we will enjoy an increase of not less than 25 per cent over 1955 by 1960 and a 50 per cent increase over 1955 by 1965. This will mean an increased consumption of more than a billion board feet of lumber by the furniture industry in 1965 over 1955.

These increases, as spectacular as they are, could be doubled if our industry could make homemakers conscious of the need for more attractively designed furniture to replace their obsolete pieces. Coupled with this is the need for a trade-in program especially thought out to meet the needs of our industry in meeting this modern-day problem.

Research Developments

New knives and cutter heads for woodworking machines will be a tremendous development in the next ten years. Amazing instruments and machines for the research laboratory have been developed to aid in this work. Chipcore is another modern development that is going to have a definite impact when completely perfected.

High frequency glue presses are in operation advantageously in many factories and will be improved to bring greater progress to furniture manufacturing, reducing the cost of panels and creating a better bond with less repairs. Practical developments in inserting foil under veneer tops for protection against burns, and new plastic tops, are developments of importance. The urea resins have led to a notable advance in furniture manufacturing. Now we need a fast-drying glue that will make a strong bond with lumber at about 3 per cent moisture content. New sanding machines to better utilize sandpaper, a costly supply item in furniture manufacturing, are in the development stage as a result of recent research.

It has been found that individual incentives are effective in reducing costs of operations classified as day work, such as shipping, routine repairs, and lumber handling. When properly applied, these result in higher remuneration to those on the incentive system and a reduction in product cost.

When we analyze operating statements for improvements, we skip over certain expenses as "fixed", saying we cannot do anything about taxes, depreciation, fuel, freight, insurance, maintenance and power, and little about indirect labor supplies, and other such costs. Here is where I think other great savings will be made in the next ten years.

I believe that economic conditions will dictate the building of many new furniture factories in the next ten years, a development that has not taken place in this industry for many years. In a progressive and expanding industry, we should be able to secure financing of new factories. More than half the cost of fire insurance can be saved in a modern building, a sizeable item in furniture manufacturing. Also, it is surprising what competent tax accountants can do with the bugaboo of taxes when starting a new factory.

Furniture manufacturers are constantly finding greater uses of conveyorization to carry the work from one machine to another and carry away the waste to wood hogs to be automatically fed to the boilers. Conveyors increase direct labor productivity and reduce the indirect labor of material handling. Old buildings do not lend themselves to the greatest possibilities of conveyorization, which is most effective when engineered into the building when it is constructed.

Humidifying heaters can be engineered into a new factory to eliminate the cost of in-process repairs caused by widely fluctuating moisture conditions. Automatically controlled low pressure boilers can greatly reduce the expense of firemen. Coupled with adequate shaving storage bins, the purchase of coal can be eliminated and the factory run on its waste.

One of the industry's greatest needs for additional progress is college-trained executives and supervisors, and technicians to run modern equipment. There are many excellent executives from craftsmen who had incentive to acquire scholastic training, but they are not in sufficient numbers to properly manage the production of our industry. We are hoping the colleges which have furniture courses will be sufficiently patronized to be of value to the industry. Their graduates have been in great demand because the classes have not been large enough for the industry's needs.

We must be alert to all the problems that a competitive economic system imposes, but with the intelligence of our lumber sources, our equipment manufacturers, the merchants of furniture, and everyone else within the scope of this great industry combining for dynamic progress, I cannot help but foresee an expanding and progressive future for all of us.

The Author: Clyne Crawford holds A.B. and M.B.A. degrees from U. of Michigan. President of NAFM in 1954-55, Mr. Crawford has also served on several NAFM committees. He is a Past President of Jamestown Area Furniture Manufacturers, and is active in Jamestown civic affairs.

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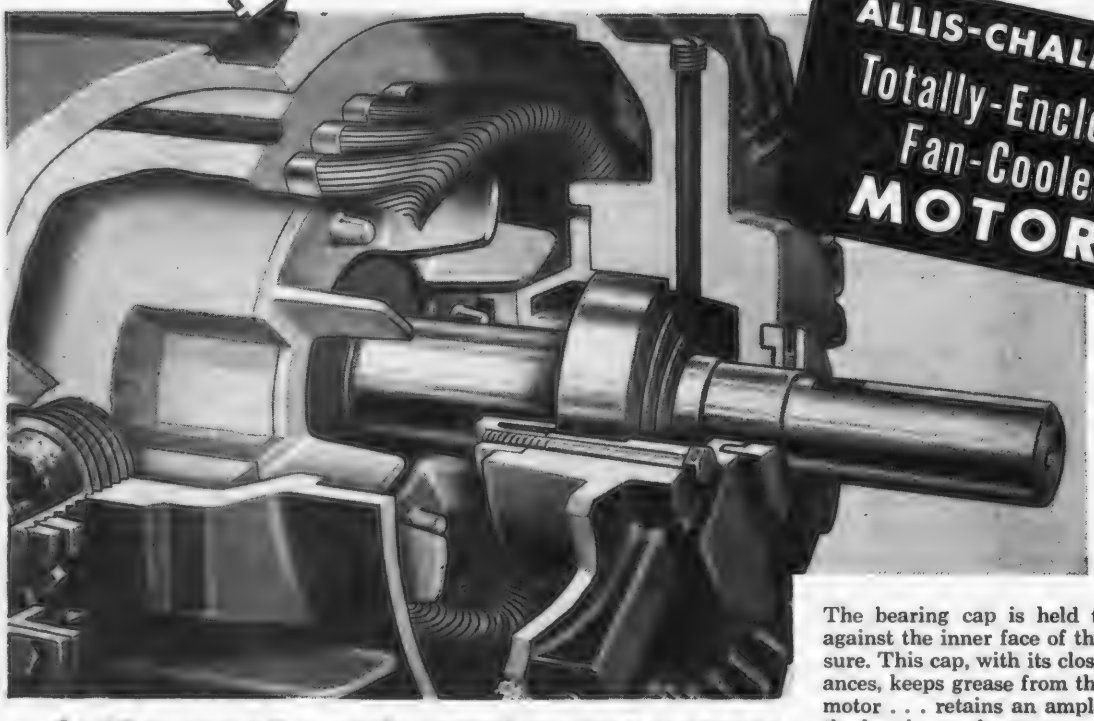

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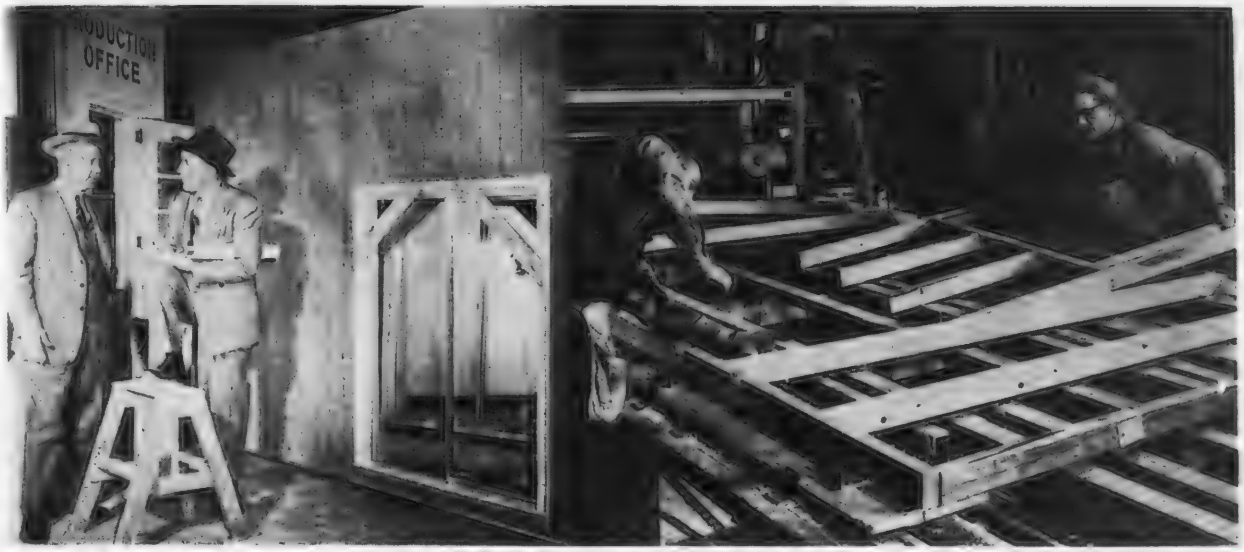


LEADING PRODUCER of prefabricated homes in U. S. is National Homes Corp., founded by James R. Price, president, left, shown checking production schedules with Hoyd A. Price, Lafayette plant manager. Right, framing jig for forming wall sections of prefab houses. Pre-cut pieces are held firmly in place until craftsmen nail them together in rigid wall section.

Problems of Utilizing Wood in Prefabricated Buildings[1]

WILLARD J. WORTH

Head, Research and Development, National Homes Corp., Lafayette, Indiana

Discusses principal problems in manufacture of prefabricated houses that need further technical study. Stress grading of small sizes of dimension lumber is urged and steps taken to solve tolerance problems are described. A solution is suggested for the need for adhesive types that can be applied at the construction site. Other problems include requirement of a water-resistant, fast-setting adhesive that will not require nails or cleats, and waste sorting and disposal.

PROBLEMS AND RESEARCH PROJECTS at National Homes Corp. are farmed out to various technical organizations that have the personnel and equipment to perform the work. These projects range from simple testing to applied research on a new adhesive. The projects are often performed with the cooperation of a building material manufacturer and occasionally such work takes place within the manufacturer's own organization.

It should be pointed out that the firm presently has three factories in operation with a combined capacity in excess of 200 houses per day. During the coming year, the firm anticipates building 30,000 homes through its builder-dealer organization in 41 states.

Thus engaged in the mass production of houses, every advantage must be taken of new materials and techniques in an effort to increase the quality of the home and lower the ultimate cost of that home to the consumer.

The largest items, in dollar volume, that are used in the construction of a prefabricated house are wood and wood products such as plywood and fiberboards. These same items compose the largest inventory item. At the present time, the company has an inventory of 6 million board feet of lumber, 2 million square feet of plywood and fiberboards. During peak production, which occurs during the summer months, dimension lumber is used at the rate of 1 million board feet per week. Thus it is obvious that we have a deep interest in the wood and wood products industry and in the future of that industry.

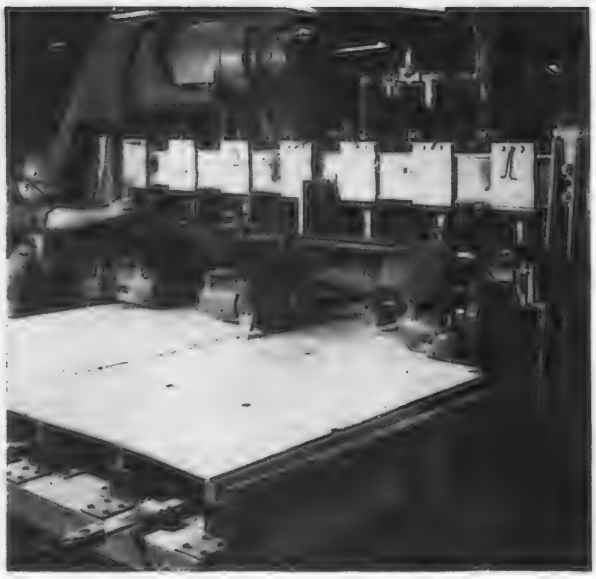
The majority of wood use in these houses comes in framing lumber: the studs, joists, rafters, and bracing that make up the structural system of the home. For this, No. 1 kiln-dried West Coast hemlock or coastal region Douglas-fir is normally used. In times of shortages of these materials, an equal grade of other species has been used.

Code Requirements

Unlike the conventional builder who constructs his house according to time-honored practices, the prefabricated house manufacturer must be in a position to prove the adequacy of both his methods and materials to a variety of agencies. These include the Federal Housing Administration and the Veteran's Administration with their regional offices, state building code com-

[1] Presented at meeting of Midwest Section, FPRS, April 11–12, 1955, in Champaign, Ill.

The Author: Willard J. Worth received B.S. degree and did advanced work in architectural engineering at U. of Illinois. A registered architect, he was employed for two years as research associate at the U. of Illinois Small Homes Council. His work has included research on the structural, economic, and code requirements of wood framing for dwellings. Worth is the designated representative to FPRS of the National Homes Corp., supporting member of the society.



AUTOMATIC NAILING machine, equipped with eight hammers driven by compressed air, can fasten a section of sheathing to framing in 30 seconds.

FINISHING TOUCHES are applied to wall sections as they come off the assembly lines. These men are putting trim on the doors and windows.

missions, national building code organizations, and building code authorities and inspectors at the county, township, and city levels. This means, among other things, completely engineered structural designs and the use of nationally known and grade-marked building materials.

The two West Coast woods mentioned, when classified according to Rules No. 14 of the West Coast Lumbermen's Association, are graded according to use. For example, a 2″ x 6″ or 2″ x 8″ is classified by use as being in the joist, beam, and plank group. This is, logically, due to the fact that the ratio of these cross sectional dimensions (depth to thickness) indicates a section that is more efficient as a beam than would be a nearly square cross section. On the other hand, a 4″ x 4″ member is classified as a post according to its expected use. Different restrictions on defects are imposed by the different use classifications and therefore the pieces are not interchangeable in use. In heavy timber construction, this system presumably has worked well and has resulted in the efficient utilization of wood.

In light wood framing, however, this system does not work. As a result of the use classification, the much used 2″ x 4″ is graded as a studding grade to be used in compression and not to be used in bending or tension. This is an important restriction that concerns both the prerabricated house manufacturer and the progressive conventional builder.

Many groups have pointed out the desirability and economy of engineered truss designs for house framing. Our roof framing system, while not clear span, is essentially a trussed roof system and is designed according to engineering principles. Obviously, the basis for any engineering design depends upon the use of stress graded material. Yet, since the principal members of truss construction are loaded in bending and tension, the 2″ x 4″ should not theoretically be used in such construction. Practically, of course, it is used.

This problem has been solved only through expensive and extensive testing of individual pieces taken in a random sampling of the lumber inventory. Even though this testing has been accomplished, in order to protect against variability from the test results, design values used are based on the lowest ranges of the test results and are considerably below those that would apply to a 2″ x 6″ of equal grade. The result is inefficient and occasionally wasteful engineering design.

In connection with the beam, joist, and plank classification mentioned earlier, although members 2″ thick, 6″ and larger deep are graded as beams, they are not necessarily graded throughout their entire length. Here again, practical use of the product in all types of building does not conform with the intended use of the grading rules.

All-Purpose Grade Needed

There is a real need for the establishment of an all purpose stress grade in dimension sizes ranging from 2″ x 2″ through the normally used sizes of light timber framing. It shall be pointed out that the existing grades of 1100f and 1450f would serve most of the needs of the prefabricator as long as those grades applied to all sizes and to the entire length of the piece.

One thing should be made clear. All testing indicates that No. 1 material as presently being graded and shipped is more than strong enough to meet the stress grades mentioned above. It is the lack of specific and written rules which would establish such material as a standard stress grade that creates the difficulty. Such grading rules exist in other species and it is hoped that some steps can be taken to relieve us of the burden of testing and to place our engineering on a more efficient and sound basis.

The present trends in both conventional and prefabricated housing toward engineered framing, and particularly toward truss construction, show that a demand exists for a product of this type.

In addition to the testing of individual materials and the preparation of a structural analysis for our methods of construction, testing is frequently performed on full scale sections of our wall panels, roofs, etc. Another thing concerning grading and strength is that many building codes make reference to or have incorporated in them allowable span tables and working stress tables that are considerably behind the present recommendations of NLMA as published in the *National Design Specifications*. This publication has been very helpful in our design and should reach wider circulation among the architects, engineers, and officials who are interested in building codes and their administration.

In common with the general trend in residential architecture, we have

developed some designs and methods of constructions that utilize exposed beams within the house. The appearance problem has been solved through the use of plywood facings that are shop glued and nailed to the solid two inch core of the beam. These faces also bring the structural member to the proper thickness to fit into a specially prepared socket in the bearing panels that support the beam.

Since it was impossible to use shims in this exposed location to provide the exact elevation for the top of the beam, a beam of exact depth with no tolerance had to be provided. Through trial and error, it was found that this could only be accomplished by trimming all members used to ¼ inch less than the standard depth—in other words variations in depth of plus or minus ¼ inch could be expected in shipments of framing lumber in the 2″ x 10″ and 2″ x 12″ size range. This particular solution was not a serious problem since the beam was a comparatively low volume item. However, it is anticipated that if the trend toward more exposed members continues, it will be necessary to find more economical methods of depth control than trimming.

Special Trimming Saws

A similar tolerance problem in the plywood used in certain applications was solved through the use of special trimming saws. In this instance, it was necessary for the roof panels to be built so that the plywood would not, under any conditions, extend more than half way across the thickness of the marginal rafter of the panel. An attempt was made to solve the problem through the use of plywood 1/16 inch shy of the standard 96-inch length. This solution did not work perfectly since a combination of human error in placing the plywood plus variations in the squareness of the plywood sheets was still capable of causing "run overs".

The problem was ultimately solved by the production department through the use of a special jig table. In addition to the stops for the framing members, this table was provided with a series of pneumatically driven nailing machines on a movable beam which also carried two trimmings saws at the edges of the panel. After the plywood has been placed upon the rafters and tacked temporarily, one pass of this machine simultaneously nails the plywood 6″ o. c. and trims the plywood edges to the exact center of the marginal rafters.

These cases have been cited to indicate some of the tolerance problems that are peculiar to the prefabricated house. In some areas of construction, the same tolerances can be permitted that exist in conventional construction. In other areas, the quick and economical erection on the building site that is strived for can only be achieved when tolerances are held at considerably lower levels. It is a continuing problem in the design of prefabricated houses to provide tolerances without affecting the appearance or the structural strength of the assembly.

The nailing and trimming machine described above is an example of the ingenuity of the production department. Many of the machines employed are unique and are designed and built for the specific purpose by the production department. Among these, the one that seems most spectacular is a machine that in a single pass accomplishes the following on a rafter—trims to length, drills and counterbores two holes to receive lag screws, cuts a single notch on the top edge and a series of 6 notches on the bottom edge, trims the overhang portion from a 2″ x 6″ to a 2″ x 4″, and cuts gains into the rafter both sides to receive blocking.

At the present time, it appears that the manufacturers of woodworking machinery do not see sufficient volume in the prefabrication industry to justify the inclusion of the prefabricator's needs into the design of their equipment. However, we believe that there are tremendous potentialities and look forward to a closer cooperation between these manufacturers and our industry.

Prefab Institute Leader Sees Greater Lumber Usage

A vast increase in lumber use for prefabricated housing can be achieved through closer cooperation between lumbermen and prefab producers, says P. S. Knox, president of Prefabricated Home Manufacturers Institute. Addressing NLMA meeting, he estimated that in 1955 prefab industry would nearly double its consumption of wood products over last year. In 1954, prefab housing consumed 400 million board feet of lumber, 250 million feet of plywood, 78 million board feet of flooring, 847,000 doors, and 52 million feet of wood trim.

Prefabs accounted for nearly 10 per cent of all single-family housing starts in 1955 and Knox predicted that 90 per cent of all houses built in next 20 years will be prefabricated.

Last year, prefabricators accounted for 6 per cent of the homebuilding in this country and this year's prophecies are running around 10 per cent. There is every reason to expect that this percentage will continue to rise and the potentialities to the woodworking machine industry will rise accordingly.

Waste Disposal

One result of this increase in volume is expected to ultimately create one of our most serious problems—waste disposal. Under present methods of operation, sub-floor conveyor belts collect waste material and transport it to a wood hog and then to a boiler where it is burned. During the winter months, this waste, when converted to steam, is sufficient to provide heat for the entire factory and adjoining offices. During the summer months, however, this heat is only used in the ovens that are part of the painting and finishing departments. As a result, waste disposal is at its lowest efficiency during the period of greatest production. We are therefore interested in finding more economical methods of waste conversion on a year round basis or of finding economical methods of disposal on a seasonal basis.

One of the most difficult obstacles to more efficient use of the waste is the problem of sorting—it normally consists of sawdust and trimmings of wood, plywood, hardboard, and fiberboard. The production department has considered several solutions and is continuing to look for other possibilities.

Gluing Problems

Another area of considerable interest to prefabricators is the field of adhesives, as applied to wood and wood products. The basic method of construction for roof, ceiling, and wall panels includes the use of adhesives in the connection of the sheathing and finish materials to the framing members. Since the application of heat or long pressure periods is not possible under the production line set-up, the technique of glue-nailing is used.

The framing members are placed in a jig, the panel is squared by compressed air, and the surface of the framing is covered with glue through the use of a glue gun. The skin material is placed and the skin nailed to the framing with either manually or pneumatically driven nails and cleats. Immediately upon completion of this operation, the panel is moved to the next station where openings for windows, doors, etc. are routed. In this brief period, it is necessary for sufficient bond to be established so that the panel will remain squared during the rest of the fabrication process.

This system works very well with sheathing materials that will be covered by site applied finish materials. With finish surface materials, it has the obvious drawback of requiring spackling or some other treatment of the nail holes.

An adhesive has been sought that is capable of performing this same function without the need for nails or cleats. Such an adhesive must be water resistant and capable of establishing a "quick grab" that will hold the panel in square after a pressure period of 30 seconds at approximately 190 psi. Preferably it should be applicable to fiberboards, foil-backed boards, and plywood. It should develop sufficient strength under normal conditions of aging and use that shear failures would be expected within the skin materials (with the exception of plywood) rather than in the glue line.

The basic laboratory testing on possible adhesives for this use has been completed and certain deficiencies in the original formulation have been noted. Test panels using this adhesive have also been unsatisfactory and the test adhesive has been changed. Work is expected to continue on this project and further test panels will be erected as part of homes located in several different geographical areas. From these experiments, comparative data will be derived over a period of a year or two, between these panels and conventionally constructed panels.

If the results of this field test are favorable, a tremendous advance can be made in the quality and appearance of our product without a prohibitive cost increase. This will also result in a more uniform wall surface and one that is free from the hazards of nail popping, spotting, etc.

Field Gluing

Another use of wood adhesives expected to be of increasing importance to the prefabricator will be their use in the site erection of the house. As mentioned earlier, a trussed roof construction is utilized on some of the houses. After the exterior walls and the bearing partitions have been placed, the ceiling panels are placed and connected to the supporting walls. Roof panels are then lifted to the deck formed by the ceiling and erected to form the basic triangle of the roof construction. At the heel joints of this triangle, specially prepared notches in each ceiling joist will receive projections on each rafter. Pre-drilled holes in both joists and rafters line up to receive a lag screw that will also connect the roof to the wall construction. Under the design live load of 40 psf, the shear that must be developed at this point is considerable. In addition to complex notching, at present shop-applied shear blocks are glued and nailed to the rafters.

As this basic triangle is braced out to form the trussed construction, other high shear values are encountered that are presently being carried through the use of mechanical fasteners, such as nails, bolts, and lag screws in combination with special steel hangers, sockets and splice plates.

It is believed that many of these joints could be made much more economically if the proper adhesives and techniques could be developed for site gluing. You may be familiar with the recent glue-nailed truss designs published by the Illinois Small Homes Council. However, the use we are suggesting is more specialized and peculiar to prefabrication, since the joints mentioned must be made within the confines of the attic space and after the assembly of the basic roof triangle.

Suggested Approach

The following suggestion may or may not be a practical approach to the problem. Two prime factors have delayed the wider use of field gluing: the first is the difficulty of maintaining field control over the quality of the adhesive and those factors that influence the efficiency of the joint; the second is reluctance on the part of the builder and the mechanic to becomes involved in what is basically a messy operation—the application of liquid glue with brushes or rollers. This last point is especially important to the erector of a prefabricated house, since he is dealing with panels that already include the final finish material of the house and in some cases these may have a factory applied finish. Leakage, squeeze out, and occasional accidents (remembering that the mechanic is working within the confines of an attic) would result in expensive repairs that would quickly offset the potential saving.

However, it is suggested that an adhesive film be laid between two protective coverings at the factory of the adhesive manufacturer. Under the controlled conditions of a factory operation, this film could be laid at the optimum conditions of temperature and humidity and to the optimum thickness for the intended use—not so thick as to be wasteful, not so thin as to result in a substandard or starved joint. This material, shipped as rolls or flat sheets, could be efficiently handled at the building site and could be cut as needed to assemble individual joints.

The stripping of one covering would expose one surface of the film which would then be pressed to the surface of one of the pieces being joined. The other protective layer could then be stripped and the second member of the joint placed. Bonding pressure could be established through nailing.

In the case of plywood splice plates, etc., the first step of the above sequence might possibly be completed in the prefabricator's shop, and these items shipped ready for the final assembly in the field.

It is understood that films of this nature are currently being manufactured using pressure sensitive adhesives which are suitable for the application of tile and products of this nature. It is also understood that these adhesives are not suitable in structural applications, since they exhibit properties of cold flow and creep when loaded at the values necessary for developing the full shear strength of the members being joined.

However, it is believed that this same basic idea could be extended to include water resistant or waterproof adhesives that would develop strength and durability comparable to that which can currently be achieved at an economical level through the use of the fortified caseins.

Conclusion

We have a great deal of faith in the continuing importance of wood framing and wood products in all residential construction. If radical changes in building methods (through the use of core materials and sandwich construction) develop, we expect wood products to figure prominently in such a development.

In the meantime, we would like to make fuller utilization of the wood framing and products that are part of our present method of construction. This can be done through an improvement in the stress grading of framing material and through the development of better structural connection devices.

These, in connection with better production techniques and improvements in our own methods through research, will lead to an overall improvement of our product.

A New Method for Testing Wood Adhesives: II. Test Apparatus[1]

ALAN A. MARRA

Assistant Professor, Department of Wood Technology, School of Natural Resources, University of Michigan, Ann Arbor

A simple machine and test procedure was designed to fulfill a need existing in the furniture industry for a method of evaluating adhesives. This machine and procedure can be used in a plant or laboratory to appraise properties of assembly glues, dowel joints, screws, and other fastenings.

TO EVALUATE AN ADHESIVE, a specimen must be assembled and tested. At the point where evlauation of adhesives and gluing procedures can profitably be encouraged at the point of consumption—neither facilities nor personnel are normally available to carry out reliable tests. How often has the recommendation been made to refrain from overheating hot animal glue, or to avoid adding more water to over-aged mitxures; and how often has this advice been ignored because the worker was not convinced? If he could make some specimens and observe the resulting strength differences, he undoubtedly would soon learn the safe operating limits of his glue under conditions of use that prevail at his plant.

This paper describes the development of a simple machine and test procedure which could be used in the shop, as well as in the laboratory, to aid in appraising properties of assembly adhesives, dowel joints, screws, and other fastenings. It is based upon the use of the cross-lap specimen discussed in the first paper of this series.

As a means of obtaining data upon which to base decisions regarding adhesive properties, strength tests presuppose accuracy in the fabrication of the specimen, and in the loading and gripping apparatus for breaking it. Since these factors have an appreciable bearing on a particular strength observation, minimizing their effects is an important consideration in a test procedure.

[1] Second in a series of contributed papers based on a thesis submitted in partial fulfillment of requirements for the Ph. D. degree at the University of Michigan.

The Author: Alan A. Marra holds B.S. and M.S. degrees from New York State College of Forestry, Ph.D. from University of Michigan. He was associated with Engineering Research Corp., Riverdale, Md.; Plywood, Inc., Oshkosh, Wis.; and Monsanto Chemical Co. before joining Michigan faculty. A charter member of FPRS, Marra is Chairman of FPRS Glues and Gluing Committee.

Specimen Fabrication Factors

As far as fabrication factors are concerned, it was indicated in the previous paper that the cross-lap specimen appears to provide a high degree of uniformity because of the manner in which it can be assembled. Since the wood blocks comprising the specimen can be surfaced in long strips, and subsequently assembled individually, the joint should be relatively free from surface irregularities and should produce intimate contact with a minimum of pressure.

The effects of variability inherent in wood, such as grain direction and density, may be minimized by proper statistical design, employing either a split plot technique which balances out differences directly, or a randomization method which assures unbiased distribution of unknown wood variables. The statistical aspects of controlling wood variables will be covered in a future paper.

F.g. 1.—Self-aligning grips.

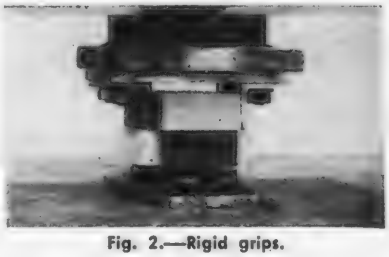


Fig. 2.—Rigid grips.

Types of Grips

In testing the specimen, two distinct types of grips have been used by earleir workers. These may be broadly classified as(a)self-aligning and (b) rigid. The self-aligning grip, as the name implies, is responsive to forces both parallel and perpendicular to the load axis, and tends to align itself in such manner as to equalize the load in geometrically similar parts of the specimen. For example, the corners or sides of the specimen should be under equal load.

Fig. 1 shows a self-aligning grip. It is similar in design to that used by other workers. The chief feature of this grip is that each of the four bearing edges are individually suspended and pivoted at right angles from a circular connecting beam. The beam in turn is joined to the loading mechanism through a universal joint.

Each bearing edge can adjust itself independently of the other three. The actual bearing edge consists of a short rod 1/4-inch in diameter, positioned to contact the specimen 0.2 inch from the edge of the glue line. This grip may be mounted on any machine capable of delivering controlled tensile loads.

The rigid grip, exemplified in Fig. 2, cannot conform to irregularities in alignment between the specimen and the machine. When used in a universal testing machine, the bearing edges deliver the load at points of highest elevation, irrespective of yielding or weakness that may occur elsewhere. While the load in this case is supplied as a compressive force, it nevertheless also reaches the glue line as tensile force components.

If specimens and testing machines could be made with absolute precision, either grip should theoretically produce the same result. Since such a situation cannot be assured, it is of interest to speculate upon the relative merits of the two types of grips in a test procedure.

The degree to which the grips respond to local defects in the bond, or their ability to propagate initial failure, would largely determine the maximum strength observable in a given instance, assuming no testing machine irregularities. On the basis of their action under load, it would appear that the self-aligning grip might lead to the higher values since it could act to reduce the build-up of stresses resulting from a shifting resistance pattern of the bond as local yield levels are reached.

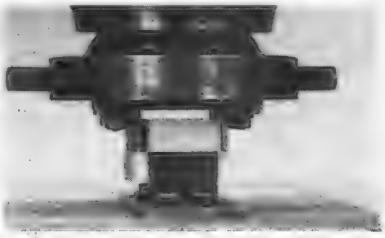


Fig. 3.—Rigid grip with load applied through half-round bearing block.

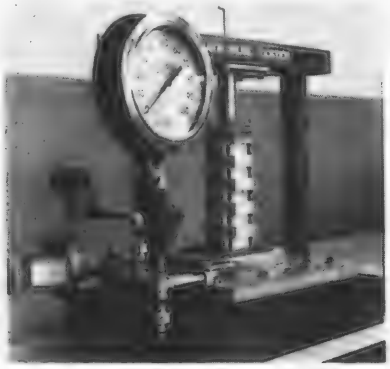


Fig. 4.—NAFM Glue Tester set up for preparing specimens.

Fig. 5.—NAFM Glue Tester set up for breaking specimens.

Fig. 6.—Assembly jigs for holding cross-lap specimens during cure of adhesive.

A question then arises: Which would be the true value, the higher or the lower; that is, which value would more nearly represent the actual condition of the bond? This would appear to depend upon the use to be made of the data. There may be instances where it may be desirable to accentuate voids or other bond defects.

In the absence of prior knowledge, it would seem appropriate to devise a combination of the characteristics of the two grips. An obvious means of accomplishing this is either to increase the flexibility of the rigid grips or reduce the flexibility of the self-aligning grips. One system for imparting a degree of angular movement to the rigid grips would be through the use of a half-round bearing block, Fig. 3. A similar degree of movement could be obtained with the self-aligning grips by making each pair of bearing brackets integral with the connecting beam, but retaining the universal joint.

In developing a test apparatus, incorporating simplicity of design and operation, the mechanics of producing stress appeared to be in favor of compression rather than tension loading. Moreover, a machine delivering compressive loads could then also be used for applying bonding pressure in making specimens. A rigid type grip was therefore selected as the starting point in the construction of a machine, flexibility in angular movement of bearing edges being achieved by means of a fluid loading system.

Comparisons in revealing power between this system and the completely self-aligning grip are the subject of a later experiment. Much of the subsequent investigations were carried on with the self-aligning grips since the chief concern was with the properties of the specimen. It was felt necessary to eliminate, in-so-far as possible, the influence of testing machine, eccentric loading, and local bond defects not associated with a strength measurement intended to relate effects of imposed variables.

Testing Machines[2]

The machine which evolved through many modifications is pictured in Figs. 4 and 5. It is based upon the use of a diaphragm to deliver compressive loads and provide the necessary measure of equalization. By interchanging fixtures, the machine may be used as a press for making cross-lap specimens, Fig. 4, or as a testing machine for breaking them, Fig. 5. Specimens are assembled in special jigs, Fig. 6, which serve as a means of keeping them in proper alignment, and also for retaining pressure until the adhesive hardens.

The machine itself is constructed mostly of standard parts. The diaphragm is a sheet of rubber, circularly restrained by a plywood ring bolted to a sheet metal base, Fig. 7. Air pressure is the actuating medium, although water or other fluid pressure may be used. The force developed by the diaphragm is delivered to a circular plate which carries the fixtures for holding the specimens. Since this plate floats on the diaphragm, it has freedom to adjust to the resistance pattern offered from above. The plate has an area of 50 square inches, and hence the force produced is 50 times the line pressure. Since the total upward travel of the plate is one-half inch, the diaphragm is not appreciably stretched.

When set up to make specimens, Fig. 4, the machine carries a short stub which delivers pressure to the center of the stack. This stub is drilled to receive a ¼-inch rod. The rod locks the stub in place on the upper cross member and at the same time engages a small hole in the center of the plate on top of the specimens. When bonding pressure is applied, the rod guides the jig full of specimens vertically to the center of the stub.

Fig. 5 shows the machine set up for testing specimens. The stub has been replaced by a built-up I-beam arrangement, locked in place by the same ¼-inch rod. It carries two parellel bearing edges, two inches apart at its lower end. These bearing edges span the top member of the cross-lap specimen to apply a compressive load on the bottom member. The specimen itself is mounted on another fixture, also carrying two bearing edges perpendicular to the upper pair. These bearing edges span the bottom member of the speciment to apply a compressive load on the top member. The combined action of the two pairs of bearing edges exerts a tensile load on the adhesive bond.

All fixtures are built on 4 x 4-inch steel plates. Every plate is drilled with a ¼-inch center hole, including the pressure plate floating on the diphragm, and the members of the frame. Since all such holes must be on the same vertical line, it is possible to check their alignment by means of a ¼-inch rod threaded through the entire machine when assembled.

For testing specimens, the air being delivered to the machine is first reduced to a uniform 100 pounds per square inch by an air regulating valve.

[2] This portion of the research was done under the sponsorship of the National Association of Furniture Manufactures. The machine which was developed carries the name NAFM Glue Tester in recognition of this support. The design and construction of the machine was the result of the efforts of several persons, those of L. A. Patrosky and G. P. Bruneau being particularly helpful.

In order to maintain a constant rate of loading, this incoming air then passes through a flow control valve before entering the diaphragm chamber.

A pressure gauge scaled in one-pound divisions, protected by a check valve, is used to observe the load applied. The force system was checked and the guage dial calibrated by removing the superstructure and allowing the pressure plate to contact the crosshead of a universal testing machine.

Since a one-pound reading on the gauge is equivalent to 50 pounds load, a means of increasing the precision of the machine was used in the conduct of experiments. This was done by attaching SR–4 strain gauges to the upper cross member which bends slightly under the test load. After calibrating against known loads, the system was capable of registering loads as small as 2½ pounds. In a similar manner, a Dillon Tester was made to read loads down to 1½-pound intervals by attaching the SR–4 strain gauges to the suspension beam in the dynamometer. The method by which this was accomplished will be discussed in a later paper.

Test Procedure

In the conduct of a test, a number of wood blocks are prepared, usually from strips of lumber yielding 10 or more blocks, incorporating any surfacing variables that may be intended. The specimens are assembled, five per jig, imposing adhesive variables as desired, and placed in the machine to receive the designated bonding pressure. Thumbnuts are then tightended on the rods of the assembly jig, and the stack of specimens is set aside for the adhesive to harden. When the specimens are ready to be tested, the appropriate fixtures are placed in the machine. The fixture carrying the specimen is self-locating, and force is applied automatically to all edges of the bond.

Comparison of Adhesives

To illustrate whether this procedure possessed ability to reveal differences between various adhesives, a number of specimens were made with several adhesives selected at random from those available. The gluing conditions used were 15 minutes closed assembly time, 100 pounds per square inch bonding pressure, 24 hours under pressure, and 7 days conditioning at 75° F. and E.M.C. equivalent to the moisture content of the wood prior to gluing. The amount of adhesive applied was not measured but was spread by brush and, judging by the squeeze-out, was considered adequate. As an additional point of comparison, two widely different wood moisture contents were included.

Plans and Apparatus Available

Blueprints, operation manual, and names of machine companies prepared to build the NAFM Glue Tester on custom basis may be obtained from National Assoc. of Furniture Manufacturers, 666 Lake Shore Dr., Chicago, Ill. One firm sells the apparatus for $330.

Table 1.—COMPARISON OF VARIOUS ADHESIVES USING CROSS-LAP METHOD

Adhesive	Strength (lbs.) and Wood Failure (%)* Per cent Wood Moisture Content 5	15
Urea Unextended	531–10	1239–10
Urea Extended 50%†	303– 0	750– 0
Urea Extended 100%	195– 0	369– 0
Resorcinol	582– 0	1014– 5
Casein	1020–25	990– 0
Polyvinyl Acetate	1920– 5	1680– 0
Hot Animal	1254–60	831–20
Liquid (cold) animal	1302– 0	1203– 5

*Each figure is the average of five observations, the figure after the dash being the per cent estimated wood failure.
†Extended with wheat flour.

The results, Table I, show striking differences. However, since the data were obtained under a narrow set of conditions, which may or may not have been favorable to some of the adhesives, no deductions should be drawn other than that, with the conditions used, apparent differences in joint strength occurred between adhesives and their reaction to wood moisture content. Fuller treatment at several combinations of the bonding variables would have shown to what extent the differences observed were due to the conditions used, how much could be ascribed to adhesive quality, and how much could be charged to inherent variability in the method. For the time being, the differences are the important consideration since they appear to justfy further investigation.

Effect of Rate of Loading on Observed Strength

Knowledge of the effect of rate of loading on observed strength is necessary for proper adjustment of testing machines. The strength of materials in general is known to be affected by the rate at which specimens are loaded. An increase in the rate of loading usually results in an increase in apparent strength. When testing a composite construction, such as the cross-lap specimen, in which a relatively plastic material, wood, is bonded by means of brittle or plastic adhesives, it is difficult to predict what a change in rate of loading might do to the observed strength of the bond.

The following experiment was set up to determine whether an effect could be observed on the cross-lap specimen which might obscure observations between different modifications of specimens and testing machines to be used in later experiments. The machine described above, for example, cannot maintain absolute control of rate of loading during a test, tending to decrease somewhat as the point of rupture is approached. No attempt was made to examine this factor in detail over the complete range of possibility but only within practical limits likely to be encountered.

Sixty specimens were made as identical as possible, using a modified urea adhesive. These were divided into twelve groups of five each, using a table of random numbers. Each group was tested at a different rate of loading beginning with 400 pounds per minute and ending with 6000 pounds per minute. Smaller intervals were

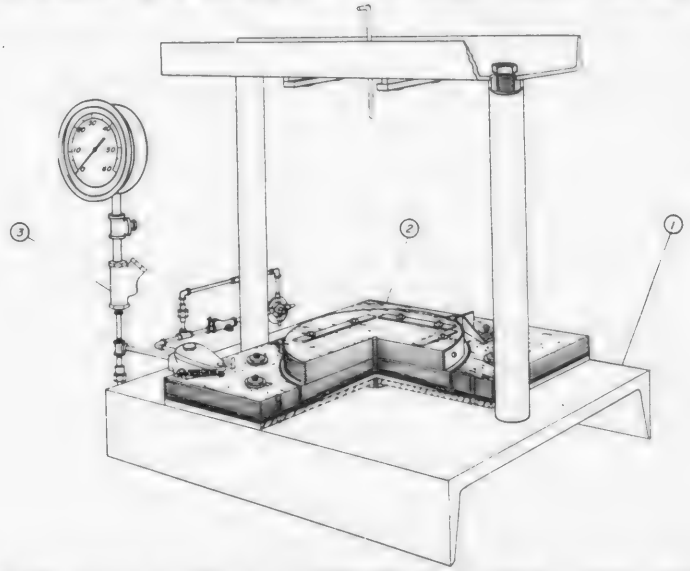


Fig. 7.—Cutaway assembly view of NAFM Glue Tester showing construction details; (1) frame, (2) loading system, and (3) pressure system.

Table 2.—EFFECT OF RATE OF LOADING ON OBSERVED STRENGTH OF CROSS-LAP SPECIMEN

Rate of Loadings*	Strength Pounds	Rate of Loading	Strength Pounds	Rate of Loading	Strength Pounds
400	1555	1250	1555	3000	1245
	1555		1605		1605
	1400		965		1455
	1300		1410		1305
	1500		1490		1225
Average	1440		1405		1365
600	1345	1500	1370	4000	1610
	1640		1290		1420
	1460		1280		1500
	1790		1250		1225
	1275		1405		1410
Average	1500		1320		1435
800	1245	1750	1150	5000	1290
	1255		1435		1580
	1410		1275		1290
	1510		1250		1480
	1365		1275		1100
Average	1355		1275		1350
1000	1470	2000	1490	6000	1160
	1320		1250		1340
	1290		1190		1325
	1445		1445		1195
	1530		1270		1470
Average	1410		1330		1300

*Pounds per minute.

Table 3.—ANALYSIS OF VARIANCE FOR RATE OF LOADING

Source	N(SS)*	DF	N(MS)	F	P
Total	81,028,400	59			
Rates	15,346,400	11	1,395,127	1.02	> .30 NS
Error	65,682,000	48	1,368,375		

*In this and subsequent analysis of variance tables,
N = total number of observations
SS = sum of squares
DF = degrees of freedom
MS = Mean squares
F = ratio of factor variance to error variance
P = probability that F can be exceeded by chance, expressed as a decimal part of a hundred
> = greater than
< = less than
NS = not significant, i.e. the factor is not likely to be a cause of variation.

used at the slower rates since this region was thought to be the most critical.

For this work, the self-aligning grips of Fig. 1 were used in a Baldwin–Tate–Emery testing machine. Table 2 shows the results. The mean strengths obtained for each group of five specimens representing different testing speeds appear to fall randomly on either side of the grand mean. That the distribution of the sample means about the grand mean was due to chance, is supported by an analysis of variance, Table 3. The variance of the means is but slightly greater than the variance of individuals, indicating that no additional variation was introduced by varying the rate of loading. As far as a test procedure is concerned, this is a favorable situation, for it implies that rather large differences in rate of loading may occur without impairing the validity of a strength observation. This, of course, holds only for the adhesive system used. It is conceivable that other adhesive bonds would respond differently to rate of loading.

Following considerations of specimen fabrication and modes of testing, a machine was developed which was believed to embody principles desirable for adhesive control and evaluation. Preliminary studies indicated that strength differences between certain wood adhesives were observable under restricted conditions, and that the specimen was not noticeably sensitive to changes in rate of loading.

A specimen and a machine do not, however, make a method. Much needs to be known regarding the sensitivity of the specimen to many factors which affect strength observations, but which may or may not be the object of study.

Several experiments were therefore initiated for the purpose of investigating a number of situations involving variables likely to be encountered. These provided data of possible interest to other workers in this field and form the subject of several subsequent papers. It is hoped that readers will respond freely with critical comment as the work is still in its infancy, and infancy is the period when there are more questions than answers.

Hot Press Gluing of Hardboards to Douglas-Fir Veneers with Phenolic Resin Adhesives[1]

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Study was made of effects of hardboard types and hardboard and veneer moisture contents on the required press time and bond quality in gluing hardboards to Douglas-fir veneers. Bond quality was evaluated by both shear tests and by a knifing technique. The data indicate that shorter press time may be used in bonding some hardboard face and back, Douglas-fir center and crossband constructions than is required for equivalent all-fir constructions.

BY COMBINING a wear-resistant, smooth, uniform surface with the strength and large panel size of Douglas-fir plywood, hardboard-faced fir plywood has become an important item of commerce. Hardboard-faced fir plywood is manufactured in conventional fir plywood plants.

Ideally, the only change in the manufacturing process to produce hardboard-faced plywood should be the substitution of hardboard for the face and back veneers. Many thousand square feet of the material have been produced in this way. In most cases no difficulty has been experienced with this procedure. However, occasionally an unsatisfactory bond between the hardboard face and the Douglas-fir crossband would result for no apparent reason. The occurence of these occasional unsatisfactory bonds was of great concern to the adhesive manufacturers and much time and effort was expended to determine their cause.

Representatives of the adhesive companies concerned were invited to present the information available regarding the gluing of hardboards with various commercial adhesives at the May 17, 1954, meeting of the Hardboard Division of the Northwest Sec-

[1] Presented at Session VII, Glues and Gluing, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

[2] Numbers in parentheses refer to literature cited.

The Author: F. J. Shelton received B.S. in chemical engineering from U. of Washington, joined Reichhold Chemicals in 1950. A FPRS member, he directs research in plywood adhesives and development of manufacturing processes for industrial chemicals.

tion of the Forest Products Research Society. Because large volumes of phenolic adhesives are used in the production of both exterior and interior type plywood, much of the discussion following the presentation of the papers centered around gluing with phenolic resins.

Two very important questions were raised for which unanimous answers could not be obtained. These were: (a) how long must the press time be for hardboard face constructions as compared to equivalent all Douglas-fir constructions, and (b) does the moisture content of the hardboard affect bond quality? A. L. Lambuth stated that his work had shown that for most hardboards somewhat shorter press times could be used than were required for corresponding all wood constructions (3). The writer's experience at that time had indicated that the rate of heat transfer through most hardboards was equal to or slower than that through Douglas-fir. Therefore, longer press times than used with corresponding all wood constructions were recommended (7).

The work reported in this paper was undertaken in an attempt to provide answers to the above questions. Also, during the course of this work a new knifing technique was compared with the shear test procedure as a means of evaluating hardboard to fir glue lines.

Press Time Requirements

In hot press bonding of a panel with a number of plies between heated platens with a thermosetting adhesive, the glue line farthest from the heated platens (usually referred to as the innermost glue line) will be the last to cure. Published pressing schedules for various hot press adhesives have been derived on the basis of providing sufficient time under heat and pressure to consolidate the plies. The innermost glue line will have cured to the point of possessing sufficient strength to allow the usual handling in unloading the press. By virtue of the heat contained in the panel, final cure to maximum strength is obtained after the panel has left the press. Generally this takes place within thirty minutes after pressing.

The time required under pressure for the innermost glue line to cure satisfactorily depends upon the rate of cure of the adhesive at the temperatures which can be obtained in the innermost glue line. The rate of cure of the adhesive is a characteristic of a given adhesive and is fixed once the adhesive has been selected.

The temperature which can be obtained in the innermost glue line depends upon many factors, including:

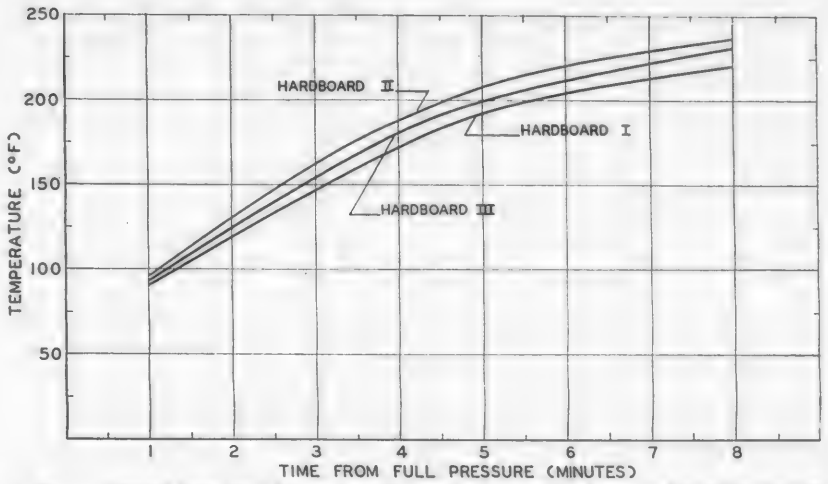


Fig. 1.—Typical inner glue line temperature curves for hardboard face and back, Douglas-fir center and core, ¾-inch, 5-ply constructions. Platen Temperature—285° F.; Pressure—200 psi; Hardboard MC—2 per cent; Veneer MC—8 per cent.

thickness of the panel, temperature of the platens, distance from the platen to the glue line, and the thermal diffusivity of the substance. In the case of wood, thermal diffusivity is a function of the specific gravity of the wood, the direction in which the heat travels through the wood, and the moisture content of the wood.

The temperature at any point in a solid may be calculated using the curves derived by Gurney and Lurie (2) (further explained by Norris (6)), or by use of the diffusivity factors and equations presented by Maclean (5). However, in the study of required pressing times, one soon finds that the inherent variations in veneer, especially Douglas-fir veneer, are so great that the use of theoretical data is seriously limited. Because of these variations, large safety factors must be used in actual practice.

For the determination of pressing times for a new construction, a more direct way is to determine the innermost glue line temperature curve by placing a thermocouple in the glue line and pressing the assembly. In this way a plot of the innermost glue line temperature versus time under full pressure for a given platen temperature can be obtained. An example of such a curve is shown in Fig. 1.

As the rate of cure of most phenolic adhesives does not become appreciable until a temperature of about 220° F. has been reached, a comparison of the time required to reach this temperature for the new construction will give a good indication of the required press time. The proposed press time can then be verified by the production and testing of a small number of panels. An interesting determination of required pressing times based upon measured glue line temperature was presented by Grinsfelder and Collins (1).

Experimental Procedure: To gain information about the relative rates of temperature increase in the innermost glue lines of hardboard-faced plywood as compared to all Douglas-fir construction, innermost glue line temperature curves were determined. From these curves, the time required to reach 220° F. for each panel was determined. Panels reaching 220° F. in the shortest length of time require the shortest total press time.

For this study three types of hardboard, one each of the smooth two side-treated, screen back-treated, and screen back-standard board types, were selected. All hardboards were 1/10 inch thick. The construction used throughout this study was ¾-inch 5 ply made from 1/10-inch faces and backs and 3/16-inch centers and cores. In the case of screen-back boards, the screen back was adjacent to the glue line.

Moisture Content: As the rate of heat transfer through veneers is markedly affected by veneer moisture content, four moisture content combinations were included in this study. Veneer and hardboard moisture contents of approximately 2 and 8 per cent were obtained by conditioning in sealed 55-gallon open head drums over anhydrous calcium chloride and 30 pounds of sodium dichromate in 17 pounds of water, respectively.

The measured moisture contents at the time of use were 2% ± 0.25% and 8% ± 2%. The four moisture content combinations used were:

a. 8% face and 8% core and center stock
b. 8% face and 2% core and center stock
c. 2% face and 8% core and center stock
d. 2% face and 2% core and center stock

Douglas fir veneer used was neither extremely hard or soft, but could be classified as moderately hard grained.

Temperature Measurement: To obtain the innermost glue line temperatures, an iron-constantan thermocouple was placed in the glue line before pressing and pressed in the panel—actually becoming a part of the panel. During the pressing operation the emf developed in the thermocouple was measured with a calibrated potentiometer and read and recorded as equivalent temperature. To cause a minimum of disruption of panel thickness and pressure distribution, the thermocouples were constructed from #26 wire.

Twenty-four 12-inch x 24-inch hardboard face and back panels were made, one for each hardboard type and moisture content combination with each of two glues. The glues selected were representative of exterior adhesives in use in the Douglas-fir plywood industry. Glue 1 uses a 50% non-volatile content phenolic resin and has a longer press time requirement than glue 2. Glue 2 uses a 41% non-volatile content phenolic resin. Both are approved by the Douglas Fir Plywood Association for the production of exterior type plywood.

The wet glue spreads used were 55 and 60 pounds per 1,000 square feet of double glue line for glues 1 and 2 respectively. Panels were assembled, given 10 minutes closed assembly time, placed in the press, thermocouple inserted three inches in from the edge of the panel in the innermost glue line, then pressed at 200 psi with a platen temperature of 285° F. The panels were pressed 9½ minutes for those made with glue 1 and 8 minutes for those made with glue 2. These press times were one minute longer than recommended for all Douglas-fir constructions.

Innermost glue line temperature readings were taken every minute for the first six minutes and every half minute thereafter. At the end of the pressing period, the panels were removed from the press and stacked in a hot stacking box overnight before being tested as described later in this paper. The temperature data were plotted and from the curves obtained the time to reach 220° F. was determined.

Eight panels having Douglas-fir faces and backs were then made, using the same glue and moisture content combinations. The procedure as outlined above was followed. The temperature data were then analyzed and an additional 24 12-inch x 12-inch

Table 1.—TIME IN MINUTES REQUIRED TO OBTAIN INNER GLUE TEMPERATURE OF 220° F.

Face Material	Glue	A 8% Face 8% Veneer		B 8% Face 2% Veneer		C 2% Face 8% Veneer		D 2% Face 2% Veneer	
		1	2	1	2	1	2	1	2
Hardboard I		6.8	7.1	5.2	5.8	6.5	8.0	6.6	6.7
Hardboard II		5.7	5.6	5.5	6.0	6.4	6.5	6.8	6.2
Hardboard III		5.7	7.1	5.5	5.1	6.7	5.8	6.8	6.6
Douglas-Fir		6.6	7.1	5.7	6.4	8.4	8.0	6.6	7.1

$\Sigma H_{I1} = 25.1$ $\Sigma H_{I2} = 27.6$ $\Sigma H_{I} = 52.7$

$\Sigma H_{II1} = 24.4$ $\Sigma H_{II2} = 24.3$ $\Sigma H_{II} = 48.7$

$\Sigma H_{III1} = 24.7$ $\Sigma H_{III2} = 24.6$ $\Sigma H_{III} = 49.3$

$\Sigma D_{f1} = 27.3$ $\Sigma D_{f2} = 28.6$ $\Sigma D_{f} = 55.9$

$\Sigma A_1 = 24.8$ $\Sigma A_2 = 26.9$ $\Sigma B_1 = 21.9$ $\Sigma B_2 = 23.3$ $\Sigma C_1 = 28.0$ $\Sigma C_2 = 28.3$ $\Sigma D_1 = 26.8$ $\Sigma D_2 = 26.6$

$\Sigma A = 51.7$ $\Sigma B = 45.2$ $\Sigma C = 56.3$ $\Sigma D = 53.4$

$\Sigma G_1 = 101.5$ $\Sigma G_2 = 105.1$ $\Sigma G = 206.6$

$\Sigma X_2 = 206.6$

$\Sigma X_2 = 353.46$

$(\Sigma X) = 42683.6$

$\frac{(\Sigma X)^2}{n} = 1333.86$

Note: Figures outside boxed area are values required in the analysis of variance calculations.

Table 2.—MASTER TABLE FOR THE ANALYSIS OF VARIANCE OF THE TIME IN MINUTES REQUIRED TO OBTAIN AN INNER GLUE LINE TEMPERATURE OF 220° F.

Degrees of Freedom		Source of Variation	Net Sum Squares	Mean Squares	F Ratio	Signif.
31	TOTAL	GGS 1353.46				
		1333.86				
			19.60	19.60		
3	Face Material	GGS 1338.04				
		1333.86				*
			4.18	4.18	1.39	5.35 (3.86)
3	Moisture Content Combination	GGS 1342.15				
		1333.86				**
			8.29	8.29	2.76	10.61 (6.99)
1	Glue	GGS 1334.37				
		1333.86				
			.41	0.41	0.41	<1 ----
9	Face Material X Moisture Content Combination	GGS 1349.73				
		1333.86				
			15.87			
			—4.18			
			8.29	3.40	0.38	<1 ----
3	Face Material X Glues	GGS 1339.03				
		1333.86				
			5.17			
			—4.59			
			.58	.58	.19	<1 ----
3	Moisture Content Combination X Glue	GGS 1342.96				
		1333.86				
			9.10			
			8.70			
			.40	.40	.13	<1 ----
9	ERROR	---		2.34	0.26	----

JSD Face Material & M. C. C. $2.26\sqrt{(0.26)(0.25)} = 0.576$ $3.25\sqrt{(0.26)(0.25)} = 0.829$

Table 5.—INNER GLUE LINE TEMPERATURE FOR ALL DOUGLAS-FIR CONSTRUCTION USING ADHESIVES 1 AND 2. PLATEN TEMPERATURE—285°. ¾-INCH 5-PLY CONSTRUCTION. READING DEGREES F.

Glue Press Time (Minutes)	MOISTURE CONTENT COMBINATION: 8% Face 8% Core and Cen.		2% Face 8% Core and Cen.		8% Face 2% Core and Cen.		2% Face 2% Core and Cen.	
	1	2	1	2	1	2	1	2
0	80	81	78	81	79	78	81	8
1	80	83	84	82	85	84	97	9
2	104	120	110	108	132	119	132	12
3	134	142	138	135	162	152	160	15
4	168	166	159	160	188	180	181	17
4½	180	178	169	170	198	188	196	18
5	192	188	177	180	209	196	201	19
5½	200	196	186	188	217	205	206	20
6	210	204	194	195	224	213	213	20
6½	218	211	200	202	228	221	220	21
7	226	218	207	209	230	227	225	21
7½	233	224	212	215	232	232	230	22
8	238	229	216	219	234	236	234	22
8½	242	233	220	224	238	240	237	23
9	246	236	223	228	240	242	240	23

panels were made. The same four moisture content combinations were used. Twelve of the panels had faces and backs of hardboard III and 12 were all Douglas-fir. Glue 2 was used throughout.

For each of the two face stocks and each of the four moisture content combinations, three panels were made—one at 7 minutes, one at 6½ minutes, and one at 6 minutes press time. Immediately after pressing, these panels were removed from the press and placed upon a rack exposed to the air on all sides and allowed to cool. As soon as they had cooled to below 90° F., ten standard shear specimens 1-inch x 3¼-inch with a one-square-inch shear area were cut from each panel. These specimens were subjected to the two-cycle boil test, which consists of the following:

a. submersion in boiling water for 4 hours.
b. drying for 20 hours at room temperature
c. submersion again for 4 hours in boiling water
d. placed in a tensile shear machine and broken
e. allowed to dry and the per cent wood failure estimated and averaged.

Results and Discussion: The time required to reach 220° F. after the application of full pressure is shown in Table 1. The inner glue line temperature data from which this information was obtained are shown in Tables 3, 4, and 5, and were plotted to provide graphs such as the one shown in Fig. 1. From these graphs the data shown is Table 1 were obtained.

Subjecting the data of Table 1 to the procedure of the analysis of variance as shown in Table 2, it was found that the type of face material significantly (95% level) affected the time required to reach 220° F. and that the moisture content combination very significantly (99% level) affected the time required to reach 220° F. Panels made from hardboards II and III reached 220° F. significantly faster than the panels with hardboard I or Douglas-fir faces. Of the moisture content combinations, the 8% face—2% core and center construction reached 220° F. in a very significantly shorter time than any of the others.

These data indicate that shorter press times will be required for panels made with faces and backs of hardboards II and III than will be required

Table 3.—INNER GLUE LINE TEMPERATURE WITH ADHESIVE 1—HARDBOARD AND DOUGLAS-FIR CONSTRUCTION. PLATEN TEMPERATURE—285° F. ¾-INCH 5-PLY CONSTRUCTION. READINGS IN DEGREES F.

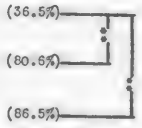
	MOISTURE CONTENT COMBINATION											
	8% Hardboard 8% Veneer			2% Hardboard 8% Veneer			8% Hardboard 2% Veneer			2% Hardboard 2% Veneer		
Hardboard Press Time (Minutes)	I	II	III	I	II	III	I	II	III	I	II	III
0	72	70	73	71	73	73	77	78	78	75	80	77
1	84	130	90	90	93	95	94	92	92	94	94	92
2	117	150	123	122	126	124	136	137	130	128	124	121
3	148	188	158	155	158	154	164	164	164	156	156	153
4	174	205	185	179	178	178	196	193	192	180	178	176
5	194	215	209	200	199	197	216	213	212	200	197	198
6	211	221	223	215	213	210	230	224	226	213	211	211
6½	218	222	228	219	220	217	233	225	234	218	217	216
7	220	223	232	224	224	222	236	226	241	225	224	223
7½	222	225	235	228	228	226	240	227	244	230	226	225
8	224	226	238	232	232	229	243	228	247	233	232	229
8½	227	227	241	236	235	232	247	229	249	236	236	231
9	228	228	343	237	236	234	248	231	250	240	240	233
9½	230	239	244	237	237	235	249	232	251	241	241	234

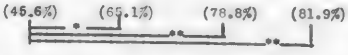
Table 4.—INNER GLUE LINE TEMPERATURE WITH ADHESIVE 2—HARDBOARD AND DOUGLAS-FIR CONSTRUCTION. PLATEN TEMPERATURE—285° F. ¾-INCH 5-PLY CONSTRUCTION. READINGS IN DEGREES F.

	MOISTURE CONTENT COMBINATION											
	8% Hardboard 8% Veneer			2% Hardboard 8% Veneer			8% Hardboard 2% Veneer			2% Hardboard 2% Veneer		
Hardboard Press Time (Minutes)	I	II	III	I	II	III	I	II	III	I	II	III
0	76	75	77	77	77	78	81	81	80	79	78	81
1	87	93	91	90	94	95	91	97	93	95	95	98
2	123	128	121	119	125	134	123	130	139	126	129	129
3	151	167	150	146	137	162	159	161	171	149	160	150
4	173	187	172	170	180	187	186	185	199	168	182	170
5	195	208	194	193	200	207	207	205	218	192	202	194
6	211	224	212	204	213	221	222	220	231	210	216	210
6½	217	229	217	210	219	226	229	226	236	217	223	218
7	219	232	220	215	224	231	233	228	240	222	229	223
7½	222	235	223	218	228	235	235	229	242	224	234	230
8	225	238	225	220	231	237	237	232	245	228	239	236

Table 7.—HARDBOARD TO DOUGLAS-FIR VENEER GLUE LINE SHEAR TEST RESULTS—TWO-CYCLE BOIL TEST

	Moisture Content Combinations							
	A 8% Hdbd 8% Veneer		B 8% Hbdb 2% Veneer		C 2% Hdbd 8% Veneer		D 2% Hdbd 2% Veneer	
Glue	1	2	1	2	1	2	1	2
Hardboard Type: Hardboard I	0	40	2	50	4	38	16	100
	0	100	3	60	11	93	36	31
Hardboard II	10	82	10	100	100	100	100	100
	30	60	98	100	100	100	99	100
Hardboard III	26	66	60	100	100	100	100	100
	33	100	100	99	100	100	100	100





Notes: Values shown are per cent hardboard and/or wood failure. Figures outside boxed area are values required in the analysis of variance calculations.

Table 6.—VARIATION IN FIBER AND/OR WOOD FAILURE WITH PRESSING TIME FOR VARIOUS MOISTURE CONTENT COMBINATIONS SPECIMENS KERFED TO BREAK AT EITHER OUTSIDE OR INSIDE GLUE LINE AND TESTED WITH THE TWO-CYCLE BOIL TEST

	MOISTURE CONTENT COMBINATIONS											
	8% Face Stock 8% Core Stock			8% Face Stock 2% Core Stock			2% Face Stock 8% Core Stock			2% Face Stock 2% Core Stock		
Press Time—Minutes	7	6½	6	7	6½	6	7	6½	6	7	6½	7
Face Stock												
Hardboard III	85	88	10	84	89	86	100	100	83	94	100	61
Douglas-Fir	87	65	36	92	98	89	85	42	0	90	63	58

Hardboard III Average for
7 Min. P.T.—90.8%
6½ Min. P.T.—94.3%
6 Min. P.T.—60.0%

Douglas-Fir Average for
7 Min. P.T.—88.5%
6½ Min. P.T.—67.0%
6 Min. P.T —45.8%

Note: Values shown are average hardboard fiber and/or wood failure for 10 specimens per panel.

for panels made from all Douglas-fir or hardboard I faces and backs—Douglas-fir core and center constructions.

These indications were then verified by making the 24 12-inch x 12-inch panels described under procedure above. The two-cycle boil test results for these panels are shown in Table 4. Comparing the average per cent wood and/or fiber failure shown in Table 4 for the panels made with corresponding press times, it was found that the panels made with hardboard III face and back averaged 94.3% wood and/or fiber failure for the 6½ minute press time, while the corresponding all Douglas-fir panels averaged 67.0% wood failure.

With hardboard III face and back, the required press time may be reduced from the recommended 7 minutes for a ¾-inch 5-ply construction to 6½ minutes. If 8% face stock and 2% core stock were to be used, possibly the press time could be reduced to 6 minutes. This possibility has little practical value on an industrial production basis, however, because of the difficulty in maintaining close tolerances on moisture content.

Table 8.—MASTER TABLE FOR THE ANALYSIS OF VARIANCE OF THE RESULTS FOR THE TWO-CYCLE BOIL TEST

Degrees of Freedom	Source of Variation			Net Sum Squares	Mean Squares	F Ratio	Signif.
47	TOTAL	GGS	290,807.0				
	CT		221,001.0	69,806.0			
			69,806.0				
1	Glues	GGS	233,708.5	12,707.5	12,707.5	27.5	** (7.82)
			221,001.0				
			12,707.5				
2	Hardboard Type	GGS	244,877.1				
			221,001.0				
			23,876.1	23,876.1	11,938.1	25.9	** (5.61)
3	Moisture Content Combination	GGS	230,831.1				
			221,001.0				**
			9,830.1	9,830.1	3,276.7	7.10	(4.72)
2	Glues X Hardboard Types	GGS	260,685.8				
			221,001.0				
			39,684.8				
			—12,707.5				
			26,977.3				
			—23,876.1				*
			3,101.2	3,101.2	1,550.6	3.36	(3.40)
3	Glues X Moisture Content Combination	GGS	247,277.1				
			221,001.0				
			26,276.1				
			—12,707.5				
			13,568.6				
			—9,830.1				NS
			3,738.5	3,738.5	1,246.2	2.70	*(3.01)
6	Hardboard Types X Moisture Content Combination	GGS	258,581.2				
			221,001.2				
			37,580.0				
			—23,876.1				
			13,604.9				
			—9,830.1				NS
			3,774.8	3,774.8	629.1	1.36	*(2.51)
6	Glues X Hardboard Types X Moisture Content Combination	GSS	249,121.5				
			221,000.0				
			58,120.5				
			—12,707.5				
			35,413.0				
			—23,876.1				
			11,536.9				
			—9,830.1				
			1,706.8	1,706.8	284.5	<1	NS
24	ERROR	GGS	69,806.0				
			58,735.0				
			11,071.0	11,071.0	461.29		

JSD Calculations—Hardboard Type $= t\sqrt{EMS\left(\frac{1}{n}+\frac{1}{n}\right)}$

$= \frac{2.06}{2.80}\sqrt{461.29\left(\frac{1}{16}+\frac{1}{16}\right)} = 7.6 \times \begin{matrix}2.06=15.66\% \\ 2.80=21.28\%\end{matrix}$

Moisture Content Combination $= \sqrt{\frac{461.29}{6}}\left(\frac{2.06}{2.80}\right) = 8.76 \times \begin{matrix}2.06=18.05\% \\ 2.80=24.53\%\end{matrix}$

Glue X Hardboard $= \sqrt{\frac{461.29}{4}}\left(\frac{2.06}{2.80}\right) = 10.75 \times \begin{matrix}2.06=22.15\% \\ 2.80=30.10\%\end{matrix}$

Moisture Content vs. Bond Quality

In the manufacture of hot press plywood, the moisture content of the veneers greatly affects the quality of the bond. With many 41% non-volatile content phenolic resins extended with walnut shell flour, veneers of 2.5% moisture content or less lead to very short assembly time tolerance with generally low wood failure results. Moisture contents of 4–6% produce best results with such adhesives.

With many 50% non-volatile content phenolic resins extended with alkali-digested Douglas-fir bark flour, low moisture contents do not cause any difficulty. But, moisture contents of 4% or higher will lead to excessive penetration and unsatisfactory bonds. The glues used in making the panels in the press time requirement study were of the types described above. Whether or not these same moisture content effects are evident when gluing hardboards to Douglas-fir veneers can be shown by testing the panels from the press time requirement study.

Experimental Procedure: The panels from the press time requirement study provided the basis for a three-factor experiment for the study of the effects of hardboard type, glue type, and moisture content combinations on the quality of the hardboard to fir bond. These 24 panels, however, were not sufficient to provide the necessary degrees of freedom for a satisfactory experiment.

To get the necessary degrees of freedom, a duplicate set of panels (12-inch x 12-inch) were prepared to serve as replications. In this way an error term for the analysis of variance containing 24 degrees of freedom was obtained. (See experimental procedure section of press time requirement study for experimental methods employed.) Since the press times used were one minute longer than normally required, the possibility of low results due to an under-cured glue line was very slight.

Test Specimens: Shear test specimens of 0.5 square inch area and kerfed to break along the outer (fir-to-hardboard) glue line were used to evaluate the bond quality. Such test specimens were previously described by R. K. Stensrud and the writer (7). These specimens were tested with the two-cycle boil test. Then specimens were cut from each panel. The average wood and/or fiber failure for the ten

specimens from each panel is shown in Table 7.

Results and Discussion: Subjecting the data of Table 7 to the procedure of the analysis of variance as shown in Table 8, it is found that all three main effects were very significant (99% level). Of the possible interactions, only the glues X hardboard type showed significance. Calculating the just significant differences and applying them to the averages shown in Table 7, the following is apparent:

a. Hardboards II and III produced better results than hardboard I.
b. Poorest results were obtained with the 8% hardboard—8% veneer moisture content combination.
3. The trend regarding moisture contents was: the lower the moisture content — the better the results.
d. Glue 2 produced better results than glue 1.

Comparison of Test Methods

The need for a rapid and sensitive test for the evaluation of hardboard to Douglas-fir glue bonds has been apparent for some time. The use of the standard shear specimen, 1-inch x 3¼-inch with a one-square-inch shear area, tested with the two-cycle boil test, was the first means of evaluation applied to such bonds. This test is the standard boil test for exterior type plywood described in Commercial Standard CS45–48.

The type of saw kerf used in this specimen did not guarantee that failure would occur in the hardboard to fir glue line in constructions comprising more than 3 plies. Modification of the kerfing—to the first glue line on one side and through all but one glue line from the other side—provided more breaks in the hardboard-to-fir glue line. However, with such an unbalanced arrangement the distribution of stresses was such as to give too much rolling shear and often failure of the hardboard in tension.

Further modification by reducing the area in shear to 0.5 square inch provided more satisfactory results with this kerfing procedure. This is the test specimen earlier described by R. K. Stensrud and the writer (7). The use of this type of specimen suffers from the fact that it is time-consuming and on occasion seems to lack sensitivity.

A more rapid and possibly more sensitive means of evaluation was described by A. L. Lambuth (4). This test, a knifing technique, was used to evaluate the panels from the moisture content study in addition to the two cycle boil test.

Two modifications of this knifing test were used. Two specimens were cut from each panel. One was knifed dry and the other after being subjected to two cycles of boiling. Shear specimens and knifing test specimens are shown in Fig. 2.

Table 9.—HARDBOARD FIR VENEER GLUE LINE TEST RESULTS—TWO-CYCLE BOIL KNIFE AND SHEAR TESTS

Hardboard Type			MOISTURE CONTENT COMBINATION A: 8% Hdbd 8% Veneer — Glue 1	A: 8% Hdbd 8% Veneer — Glue 2	B: 8% Hdbd 2% Veneer — Glue 1	B: 8% Hdbd 2% Veneer — Glue 2	C: 2% Hdbd 8% Veneer — Glue 1	C: 2% Hdbd 8% Veneer — Glue 2	D: 2% Hdbd 2% Veneer — Glue 1	D: 2% Hdbd 2% Veneer — Glue 2
Hardboard I	Shear		0	40	2	50	4	38	16	100
			0	100	3	60	11	93	36	31
	Knife		0	35	25	35	35	65	80	85
			0	65	55	80	45	60	25	95
Hardboard II	Shear		10	82	10	100	100	100	100	100
			30	60	98	100	100	100	100	100
	Knife		65	70	30	100	100	100	100	100
			20	85	30	90	100	100	100	100
Hardboard III	Shear		26	66	60	100	100	100	100	100
			33	100	100	99	100	100	100	100
	Knife		80	65	95	100	100	100	100	100
			85	50	95	80	100	100	100	100

$\Sigma H_{I_S} = 664$ $\Sigma H_{I_K} = 605$ $\Sigma H_I = 1269$

$\Sigma H_{II_S} = 1230$ $\Sigma H_{II_K} = 1230$ $\Sigma H_{II} = 2460$

$\Sigma H_{III_S} = 1364$ $\Sigma H_{III_K} = 1450$ $\Sigma H_{III_S} = 2814$

$\Sigma A_1 = 349$ $\Sigma A_2 = 818$ $\Sigma B_1 = 603$ $\Sigma B_2 = 994$ $\Sigma C_1 = 895$ $\Sigma C_2 = 1076$ $\Sigma D_1 = 957$ $\Sigma D_2 = 1111$

$\Sigma A = 1167$ $\Sigma B = 1597$ $\Sigma C = 1971$ $\Sigma D = 2068$ $\Sigma X^2 = 9803$

$\Sigma A_S = 547$ $\Sigma B_S = 762$ $\Sigma C_S = 946$ $\Sigma D_S = 983$ $\frac{\Sigma X^2}{2} = 890801$

$\Sigma A_K = 620$ $\Sigma B_K = 815$ $\Sigma C_K = 1025$ $\Sigma D_K = 1085$ $\frac{(\Sigma X)^2}{n} = 482,091.7$

$\Sigma 1 = 2604$ $\Sigma S = 3258$

$\Sigma 2 = 2999$ $\Sigma K = 2345$

Notes: Values shown are per cent hardboard and/or wood failure. Figures outside boxed area are values required in the analysis of variance calculations.

Table 10.—MASTER TABLE FOR THE ANALYSIS OF VARIANCES OF THE RESULTS FOR THE TWO-CYCLE KNIFE AND SHEAR TESTS

Degrees of Freedom	Source of Variation			Net Sum Squares	Mean Squares	F. Ratio	Signif.
95	Total	GGS	596,531.0	114,439.3			
	CT		482,091.7				
			114,439.3				
2	Moisture Content Combination	GGS	503,073.4	20,981.7	6,993.9	14.60	** (4.08)
			482,091.7				
			20,981.7				
2	Hardboard Type	GGS	519,289.9	37,198.2	18,599.1	38.83	** (4.92)
			482,091.7				
			37,198.2				
1	Glue	GGS	496,967.0	14,876.3	14,876.3	31.06	** (7.01)
			482,091.7				
			14,876.3				
1	Test	GGS	482,949.7	858.0	858.0	1.79	NS
			482,091.7				
			858.0				
6	Moisture Content Combination X Hardboard Type	GGS	543,284.8				
			482,091.7				
			60,193.1				
			20,981.7				
			39,211.4				
			37,198.2				
			2,013.2	2,013.2	371.0	<1	NS
3	Moisture Content Combination X Glue	GGS	520,961.8				
			482,091.7				
			37,870.1				
			20,981.7				
			16,888.4				
			14,876.3				
			2,012.1	2,012.1	670.7	1.40	NS
3	Moisture Content Combination X Test	GGS	504,034.4				
			482,091.7				
			21,932.7				
			20,981.7				
			951.0				
			858.0				
			93.0	93.0	31.0	<1	NS
76	Remainder			36,406.8	479.0		

The procedure for preparing knifing specimens as given by A. L. Lambuth is as follows (4):

"One by nine inch strips are cut from the panel to be tested with the direction of the grain in the veneer next to the hardboard parallel with the long dimension of the test piece. The strips are then given any exposure cycle desired, such as wet or boil tests, and are allowed to air dry until the surface water has evaporated. The hardboard faces and approximately 3/32 inch of wood veneer are sawed off the test strips. This thickness of wood was found to be about equal in stiffness to wet 1/10 inch hardboard and to give more consistent knife results than either a stiffer or more flexible wood layer. The veneer is knifed away from the hardboard and the glue line evaluated from an inspection of both surfaces. Actually, only about half of the width of the veneer should be knifed at one time, the other half being left in place for the knife to bear on. In this way the hardboard is prevented from breaking off as the knifing progresses, especially when it is wet. The most important feature of the test is knifing *away* from the hardboard. The results will reproducible when this is done."

After knifing, the per cent wood and/or fiber failure was estimated on the exposed surfaces. These data were then combined with the two cycle boil test results. The two-cycle boil knife and boil shear test results are shown in Table 9. The dry knife and two-cycle boil test results are shown in Table 11. Subjecting these data to the procedure of the analysis of variance as shown in Tables 10 and 12, it was found that there is no significant difference between either of the knife tests and the two-cycle boil shear test results.

It is strongly recommended that the dry knifing technique be further investigated as a mill test for routine quality control in the manufacture of hardboard faced plywood.

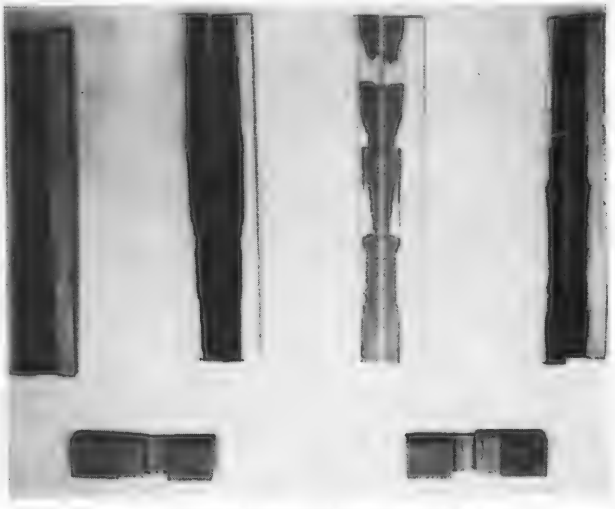


Fig. 2.—Typical knife and shear test specimens.

Table 11.—HARDBOARD TO DOUGLAS-FIR VENEER GLUE LINE TEST RESULTS—DRY KNIFE AND TWO-CYCLE BOIL TESTS

Hardboard Type		Glue	MOISTURE CONTENT COMBINATIONS A: 8% Hdbd 8% Veneer		B: 8% Hdbd 2% Veneer		C: 2% Hdbd 8% Veneer		D: 2% Hdbd 2% Veneer	
			1	2	1	2	1	2	1	2
Hardboard I	Shear		0 0	40 100	2 3	50 60	4 11	38 93	16 36	100 31
	Knife		0 0	5 5	3 40	10 10	0 20	5 22	40 35	35 60
Hardboard II	Shear		10 30	82 60	10 98	100 100	100 100	100 100	100 100	100 100
	Knife		65 30	70 85	55 40	100 90	100 100	100 100	100 100	100 100
Hardboard III	Shear		26 33	66 100	60 100	100 99	100 100	100 100	100 100	100 100
	Knife		70 70	80 45	50 70	100 85	100 100	100 95	100 100	100 100

$\Sigma H_{Is} = 584$ $\Sigma H_{Ik} = 293$ $\Sigma H_I = 877$

$\Sigma H_{IIs} = 1290$ $\Sigma H_{IIk} = 1335$ $\Sigma H_{II} = 2625$

$\Sigma H_{IIIs} = 1385$ $\Sigma H_{IIIk} = 1365$ $\Sigma H_{III} = 2749$

$\Sigma A_1 = 334$ $\Sigma A_2 = 738$ $\Sigma B_1 = 531$ $\Sigma B_2 = 904$ $\Sigma C_1 = 835$ $\Sigma C_2 = 956$ $\Sigma D_1 = 927$ $\Sigma D_2 = 1026$

$\Sigma A = 1027$ $\Sigma B = 1435$ $\Sigma C = 1791$ $\Sigma D = 1953$

$\Sigma A_s = 547$ $\Sigma B_s = 782$ $\Sigma C_s = 946$ $\Sigma D_s = 983$

$\Sigma A_k = 525$ $\Sigma B_k = 653$ $\Sigma C_k = 845$ $\Sigma D_k = 970$

$\Sigma X = 6251$

$\Sigma X^2 = 543217$

$(\Sigma X)^2 = 39075001$

$\frac{(\Sigma X)^2}{n} = 4070?1.2$

Notes: Values shown are per cent hardboard and/or wood failure. Figures outside boxed area are values required in the analysis of variance calculations.

Conclusions

1. Some hardboards are difficult to glue with standard exterior phenolic adhesives. Hardboard I, the smooth two-side board, did not bond satisfactorily under any of the conditions of this test.

2. It is possible to use press times shorter than those required for corresponding all Douglas-fir construction when certain hardboards are used as face and back material. This study indicates that the rate of heat transfer is faster through some hardboards than through Douglas-fir veneer. A study of the properties of hardboards which affect the rate of heat transfer through the hardboard would provide useful information.

3. Moisture content of the stock has a significant effect on the rate of increase of the temperature of the innermost glue line. An 8% face with 2% core-and-center gave the most rapid temperature increase.[3]

4. Moisture content of the stock used has a significant effect on hardboard to Douglas-fir veneer bond quality. This study indicates that the drier the stock, the better the bond.

5. There was no significant difference between the three tests used to evaluate the hardboard to fir glue line in this study. Because of its simplicity, the knifing technique is recommended for further study as a routine mill quality control test.

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Discussion

F. W. Herrick (Rayonier, Inc.): Can you tell us more specifically about the types of hardboards you used?

Mr. Shelton: Tempered and non-tempered boards were used. One tempered board was a rather high density board. Smooth, two-side boards were not sanded in the test.

Armin A. Wehrle (Coes Bay Lbr. Co.): Is the dried stock better for bonding?

Mr. Shelton: The lowest we used was 2 per cent. At a meeting of the Pacific Northwest Section of FPRS last year, the same subject was first taken up. The best bonds were obtained with hardboards of relatively low moisture content. There was, however, an interaction between adhesive resin type and type of board. Results of this most recent test showed dried veneer (2 per cent) gave the best results. It would be worthwhile to have further data on 2, 3, 4, 5, 6 per cent and higher moisture contents.

Mr. Wehrle: There is a practical problem involved in obtaining low moisture content in hardboard. You can't keep it in storage for a long period of time.

Mr. Shelton: It's a big advantage if you can use low moisture content board.

W. C. Walling (Dant & Russell, Inc.): Eight per cent moisture content in hardboard is an impractical range. Under most conditions, hardboard is humidified less than that. A moisture range of 4 to 6 per cent would be more practical. I notice that there was not much data in that range.

Mr. Shelton: We have done work in this range but I don't have the data with me. In this experiment, we took extremes in the M. C. range that have been encountered in actual use.

Table 12.—MASTER TABLE FOR THE ANALYSIS OF VARIANCE OF THE RESULTS FROM THE DRY KNIFE AND TWO-CYCLE BOIL TESTS

Degrees of Freedom	Source of Variation		Net Sum Squares	Mean Squares	F Ratio	Signif.
95	Total	GGS 543,415.2 407,031.0				
		136,384.2	136,384.2			
3	Moisture Content Combination	GGS 426,262.4 407,031.2				
		19,231.2	19,231.2	6,410.4	16.19	** (4.08)
2	Hardboard Type	GGS 475,523.5 407,031.2				**
		68,492.3	68,592.3	34,246.2	86.50	(4.92)
1	Glue	GGS 417,385.5 407,031.2				**
		10,354.3	10,354.3	10,354.3	26.15	(7.01)
1	Test	GGS 407,762.7 407,031.2				
		731.5	731.5	731.5	1.85	NS
6	Moisture Content Combination X Hardboard Type	GGS 498,562.8 407,031.2				
		91,531.6 19,231.2				
		72,300.4 —68,492.3				
		3,808.1	3,808.1	634.7	1.60	NS
3	Moisture Content Combination X Glues	GGS 439,878.6 407,031.2				
		32,847.4 —19,231.2				
		13,616.2 —10,354.3				
		3,261.9	3,261.9	1,087.3	2.75	NS
3	Moisture Content Combination X Test	GGS 427,408.1 407,031.2				
		20,376.9 —19,231.2				
		1,145.7 —731.5				
		414.2	414.2	138.1	1	NS
76	Remainder		30,090.7	395.9		

Sawing Hardwoods for Grade with Short-Log Bolters[1]

G. E. BELL and W. W. CALVERT

Ottawa Laboratory, Forest Products Laboratories of Canada, Division of the Forestry Branch, Department of Northern Affairs and National Resources

Short-log bolters can be used to advantage in manufacture of flat stock, especially in utilizing small and defective hardwood trees. Comparison was made by sawing similar material with a bolter and in a conventional circular sawmill. Results showed that short-log bolter can be used most effectively as a complementary unit to sawmill, rather than in competition with it.

SHORT-LOG BOLTERS originated in the New England States over 75 years ago and were used to saw square stock for the wood turning and dowel industries. They still serve primarily as producers of square stock, but their use is growing for the production of flat stock for furniture manufacture. Because short-log bolters could probably be used to advantage for the manufacture of flat stock, and because of the possibility of utilizing small and defective hardwood trees (of which Canada has a great abundance) in the manufacture of this material, the Ottawa Laboratory of the Forest Products Laboratories of Canada undertook a study of short-log bolters.

The short-log bolter appeared to offer two distinct possibilities for improving the utilization of both small and defective hardwood trees. First, since the bolter is a relatively flexible machine, and as the operator has close control of the sawing, greater care could be taken in sawing for grade and in obtaining the greatest yield from the log. Second, the bolter handles short length material, and trees could be bucked into short lengths with the consequent elimination or reduction of defective material and crook.

The actual investigations were designed to determine the following in the production of flat stock by the short log bolter:

(a) percentage lumber recovery
(b) grade recovery
(c) sawing time
(d) sawing accuracy
(e) recovery of clear cuttings
(f) general application and factors affecting the use of short-log bolters.

Costs are not presented in this paper, although this aspect of production was not overlooked. As the studies were carried out at the Research Sawmill of the F.P.L. of C., costs—on an industrial basis—would have been only theoretical and thus could be misleading. Preliminary observations also indicated that there exists considerable variation in material and labor costs between different mills and different areas. Comparison of industrial costs is also difficult because, at present, only a small number of bolter mills are in operation in Canada. However, a further study now being planned will endeavour to treat this problem as thoroughly and as realistically as possible.

Operation and Equipment

Two types of short-log bolters are manufactured: the table bolter and the carriage bolter, or short-log carriage. This paper deals only with the table bolter (Fig. 1) because of its much wider use. This type consists of a table saw, a dolly or carriage traveling on machined rails, and a folding or sliding type rip fence for quick setting. A top saw is also used in some locations where bolts of large diameter are sawn. Carriage dogs are not ordinarily used but, in some cases, can be incorporated into the general assembly.

The carriage is powered through a set of conical iron and fiber independent frictions. These are placed beneath the carriage and engaged by either foot pedals or a lever. Carriage speeds are of the following order: forward, 260 ft. per minute; backward, 330 ft. per minute.

The frame and body of the table bolter are of welded construction. Heavy steel plate, reinforced with cross braces and struts of steel channel, is used. The mandrel is of heavy duty special alloy steel 2-3/16 inches in diameter, mounted on self-aligning ball-bearing pillow-blocks. Saw diameters range between 36 and 40 inches and saw gauges generally are between 8 and 10.

Power requirements vary considerably and are dependent on the species and size of wood being sawn. General applications are: not less than 20 h.p with electric motors; not less than 35 h.p. with gasoline or Diesel engines.[2]

Saw speeds are of the following order: 36-inch diameter saw—1,050 r.p.m.; 40-inch diameter saw—945 r.p.m. Both solid and inserted tooth saws are used.

In the manufacture of squares, ripping is usually performed on a stripper. This machine is equipped with a circular table-saw and a fence. Cants and boards are fed to the machine manually and engaged by powered feed-rolls. Strippers may be of the single or multiple saw type and are located adjacent to the bolter or behind a trimmer. More than one machine may be used and combinations of gang and single strippers often are employed.

Equipment varies, of course, in different operations and is largely dependent upon the degree of mechanization in effect at a particular mill. For example, in an operation producing flat stock, the lumber is often directed from the bolter to a trim saw where major defects are removed and the material is cut to the required lengths. The stock is then directed to one or more straight-line rip saws where bark and additional defects are removed. Following this operation, the material may require a final trimming to length. Finally, the flat stock is graded and sorted for bundling and shipment. The handling of material throughout the operation may be completely or partially conveyorized.

Two points of economic significance which may stimulate further interest in bolter operations are the low raw material requirements and the relatively

[1] Presented at Session III, Logging and Milling, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash. Read by P. L. Northcott, Vancouver Laboratory, Forest Products Laboratories of Canada.

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William W. Calvert received B.S. and B.S.F. degrees from Michigan State College in 1951 and 1952. He has been forest products engineer at Ottawa Laboratory since 1952.

[2] Manufacturers' specifications.

Fig. 1.—Table bolter installed at the Research Sawmill operated at Ottawa by the Forest Products Laboratories of Canada.

Fig. 3.—Bolter produced stock, bundled and strapped, being end-coated prior to shipment from the mill.

low cost of bolter machines, auxiliary equipment, and plant.

Results of Investigations

The investigations into short-log bolter operations were conducted along two general lines: studies carried out at commercial operations and studies conducted on a short-log bolter research installation at the Ottawa Laboratory.[3] Part of these latter studies were of a comparative nature, that is, similar material[4] was sawn on a conventional circular headsaw and on the short-log bolter. This was done primarily to obtain information necessary to assess the possible general application and use of the short-log bolter.

These investigations have been based on log and bolt size and on tree size. As mentioned previously, they were designed to determine—for the short log bolter in the production of flat stock—percentage lumber recovery, grade recovery, sawing time, sawing accuracy, recovery of clear cuttings from bolter produced material, and the general application and use to whih bolters could be put.

Percentage Lumber Recovery: As expected, it was found that bolt diameter sharply influenced lumber recovery. For instance, lumber recovery ranged from between 38 and 48 per cent for 5-inch bolt to between 50 and 58 per cent for 15-inch bolts. In general, recovery figures were higher in bolter mills than in the sawmills sawing material of similar quality. This increase varied between 3 and 12 per cent, based on total solid volume of the log.

[3] The bolter was obtained on loan to F.P.L. of C. through the courtesy of the manufacturer, Forano Ltd., Plessisville, P.Q.

[4] Diameter, length and quality were kept similar in so far as was possible. Defects affecting lumber grade were appraised on the basis of U.S.D.A. publication No. 01737 (9).

Grade Recovery: Grade recovery was found to be a difficult factor to analyze. For example, depending on the type of product, various grading rules may be used which do not lend themselves readily to comparison. In these studies, some modification of existing rules was necessary. Standard lumber was graded according to the National Hardwood Lumber Association Rules for inspection of Hardwood Lumber, and short length lumber was graded according to a modification of these rules, which primarily ignored length of cuttings as one of the determining factors. Justification for this manipulation was borne out by the yields and lengths of cuttings ultimately recovered from the short lumber.

In one study on white ash, comparable trees were sawn in both the sawmill and on the bolter and the resulting lumber compared for grade.

Fig. 2.—Flat stock production on the short-log bolter—sawing a hardwood bolt parallel to the bark for higher grade recovery.

This can, perhaps, be most easily presented by combining the three best grades and expressing the results as No. 1 Common and Better. The yields (Table 1) of No. 1 Common and Better were obtained during this particular study and represent comparative values which might generally be expected to be found.

Table 1.—PER CENT OF NO. 1 COMMON AND BETTER LUMBER BY BOLT AND LOG DIAMETER CLASS

Diameter Class inches	Bolter %	Saw mill %
6	15	1
7	21	5
8	27	12
9	32	20
10	39	29
11	44	38
12	49	48
13	55	60
14	59	70
Average for all diameters	47	34

Table 1 indicates that up to 12 inches diameter (actually between 12 and 13 inches) a higher grade recovery was obtained by bolter methods than by conventional methods and that above 13 inches sawmill-produced lumber gave a more favorable grade yield.

It is felt that the explanation of these trends may be attributed almost entirely, with the exception of normal sampling error, to the usual sawmill practice of removing large slabs during the first cuts. Not only does the wood substance of such slabs usually comprise the highest quality material in the log, but moreover, the percentage of wood substance (based on total log volume) contained in these slabs increases sharply as log size decreases. As a consequence, the effect of diameter on these values is not as pronounced during bolter conversion as it is during conventional conversion, because a comparatively small slab is removed in the former method.

Sawing Time: During one study, values were recorded, for both the

bolter and the sawmill, of the time required at the headsaw in converting logs and bolts of various sizes into lumber. Since the Research Sawmill is not equipped with either the facilities nor the personnel for full production sawing, actual sawing times are of little value in comparison with commercial operations. However, since the operations were consistent throughout for both types of sawing, the comparative trends are valid and are of interest.

Table 2.—SAWING TIME IN MAN MINUTES REQUIRED TO PRODUCE 1 M. FT. B.M. OF LUMBER

Diameter Class inches	Sawmill Man min./M.	Bolter Man min./M.
5	2050	2275
6	1800	2030
7	1550	1785
8	1350	1575
9	1150	1400
10	1000	1260
11	850	1155
12	750	1085
13	700	1050
14	650	1050
15	600	1050

Sawing Accuracy: Reference to this topic is brief, but it can become an important consideration when accuracy falls below certain levels. Table 3 indicates the relative accuracies of two methods of conversion.

Table 3.—SAWING ACCURACY

	Type of Equipment	
	Bolter %	Sawmill %
Scant	5	13
Normal	94	81
Plump	1	6

It will be seen that sawing accuracy is considerably better during bolter conversion.

Recovery of Clear Cuttings: A portion of these studies was aimed at a consideration of cutting yields and lengths. It should be remembered that the results obtained are primarily comparative trends and not fixed values, and that depending upon the run of logs—or the run of lumber—these results are subject to modification.

Cuttings are defined, for purposes of these studies, as pieces 10 inches and longer, 1½ inches and wider, clear one face, and with the reverse side sound. Cuttings admit of surface checks which dress out during surfacing.

The production of clear cuttings from white ash lumber was recorded for both standard and short length lumber. Yields were related first to the lumber from which they were cut and finally to the standing tree. Table 4 shows these yield relationships.

It will be seen that there is a rather constant yield from trees which were converted by bolter methods and a variable yield—increasing with increasing diameter—from trees converted by the sawmill. This is also valid for the yields of cuttings from the resulting lumber.

These trends emphasized the fact that the effect of log or tree size is not as pronounced an influence on yields for bolter production as it is for conventional production. The reasons for this are:

1) Bolter operation for the production of flat stock is virtually an automatic parallel to the bark sawing method. The bolt is aligned visually so that the saw cut follows the taper of the bolt; all subsequent cuts on the particular face are necessarily parallel. When the bolt is turned, this process is repeated and the net result is a wedge, or tapered portion remaining in the center. This portion may be considered equivalent to the heavy slab normally removed during conventional sawing—the important distinction being that in the former method the center, or pithy heartwood, may be discarded as unusuable while high quality sapwood is wasted in the latter.

2) Another reason for increased yield is attributable to the bolt itself. Bucking a tree into short lengths upgrades the resultant raw material in three ways. First, it reduces the effect of taper; second, it reduces or eliminates crookedness; and third, it is possible to buck the tree so as to eliminate large defects. The combination of these factors together with the lower volume of slab material occasioned by them tend to increase both the quality and the yield of lumber, particularly in the smaller diameters.

Although the yield, or volume of cuttings is of importance, length of cuttings must also be considered and the necessity of appraising lumber on this basis is evident. The manufacturer, after having determined the actual yields, must estimate rather closely the sizes of cuttings which are required and the distribution of the sizes on a volume basis. Cutting bills are established periodically, but generally similar items (with regard to size) are required over long periods of time. Thus, through analyzing a representative bill, the manufacturer is able to determine what percentage of the total volume is required in the various dimensions. This may then be correlated to the distribution actually found in the factory, and depending upon the result, may either raise or lower grade requirements of rough lumber.

Figs. 4a and 4b represent the cumulative percentage yields of clear cuttings for each length class obtained during one study from standard length lumber and from short length lumber, together with a comparison of a typical sample of industry requirements.

It will be seen from these graphs that bolter produced lumber—all grades combined—may be expected to yield the required sizes as the line representing all grades falls above the line representing required sizes.[5] Any grade of lumber may be expected to yield the required sizes of clear cuttings as long as it remains above this line.

Commercial cutting bills call for cuttings which fall into a number of lengths, but there is not necessarily a continuous regular distribution of these lengths. Usually the cuttings in these bills range from 10 to 60 inches in lengths, in 5 or 6 definite length classes. In this study, cuttings ranged from 10 to 64 inches in length, in multiples of 1 inch, and were obtained by considering maximum volume obtainable with particular regard to length. In fitting these data to a particular cutting bill a certain amount of waste would occur.[6] However, it was felt that the results obtained, by cutting to maximum length, rather than

Table 4.—RECOVERY OF CLEAR CUTTINGS FOR EACH METHOD OF PRODUCTION, EXPRESSED AS A PERCENTAGE OF TOTAL TREE VOLUME AND AS A TOTAL OF LUMBER RECOVERED BY DIAMETER CLASS.*

	Bolter D. B. H. Class			Sawmill D. B. H. Class		
	8	14	20	8	14	20
Total Tree Volume (Newton's Formula) cu. ft.	16.14	52.18	120.72	15.93	51.79	100.40
Total Volume of lumber ft. b.m.	92.0	330.5	781.7	72.60	315.6	620.5
Total Volume Clear Cuttings ft. b.m.	63.81	213.54	492.55	32.25	187.13	492.82
Per cent Tree Volume Converted into Clear Cuttings %	32.95	34.10	34.00	16.87	30.11	40.90
Per cent of Total Volume of Lumber Converted into Clear Cuttings %	69.36	64.61	63.01	44.42	59.29	79.42

*The variation in yields of clear cuttings may be attributed primarily to the grade distribution of lumber from which cuttings were obtained. However, in the 20-inch D.B.H. class, an almost identical grade distribution, for both groups of lumber, produced a considerably higher yield of cuttings from standard lumber. No suitable explanation is afforded for this circumstance at the present time; however, it is felt that possibly a higher recovery of cuttings is obtainable from long, wide, high grade boards from the large diameters, than from short lengths of equivalent quality from identical diameters. Further investigation will be designed to provide an explanation of this apparent discrepancy.

[5] Cutting requirements are based upon data received from two prominent Canadian furniture manufacturers. As a close association of results was obtained, additional information from other companies was not obtained.

[6] Wylie, Aubrey E. 1954. Lumber grades and sizes in relation to product yields. Journal of F.P.R.S., IV (4):176–180. Wylie has shown that the percentage yield of cuttings increases with the number of cutting lengths in the bill; however, this increase is small. Two examples cited showed (1) the percentage increase in yield from 5 cutting lengths to an infinite number to be 3%; (2) the increase from 4 cutting lengths to an infinite number to be 4%.

to an actual cutting bill give a better general picture of what could be obtained.

General Application

These studies showed that the short-log bolter can have a definite application in improving the utilization of hardwoods. The percentage of the log or bolt volume converted into lumber is greater for the bolter than the sawmill; there is an increase in recovery of the higher grades, sawing accuracy is greater and recovery of clear cuttings is adequate to meet most cutting bills.

Capital investment is usually smaller in a bolter mill than in a sawmill but the bolter mill is at a considerable disadvantage in productivity. The time or number of man minutes required to saw 1 M ft. b.m. in a bolter mill is considerably greater than in a sawmill. However, the product of the bolter mill is of better quality than that of the normal sawmill because most of the defects have been eliminated and it usually commands a higher price.

These studies indicated, however, that the bolter is not competitive to the sawmill for the sawing of normal commercial hardwood logs. It is felt that, in most cases, the increased productivity of the sawmill materially outweighs the several advantages of the bolter when sawing this type of material. It would appear that the bolter should be considered basically as a utilization tool, since it is possible on these machines to effectively utilize smaller material and also to use defective and crooked trees that could not be classed as commercial logs for an ordinary sawmill.

One of the major objections directed towards bolter manufactured material is the comparatively large volume of short length material which is produced. However, these and other studies have shown that this volume is not materially greater than that produced by ordinary cut-out methods from standard log-length lumber. Perhaps the most convincing proof that bolter produced material can be effectively integrated into the production line of a furniture factory is the fact that a considerable number of furniture manufacturers do integrate this material into their production lines.

Flat stock produced by the bolter mill is easily handled; the usual practice is to sticker and bundle after sorting and to transport and kiln dry the material bundles, thus eliminating the handling of individual small pieces. Since bolter produced stock is largely free of defective material, little or no expense is incurred in handling useless material.

It is not suggested that the short log bolter is a cure-all or that it can be fitted into any and all situations. It does appear, however, that bolters could be advantageously used to produce furniture stock from types and sizes of trees that could not be satisfactorily used in a conventional sawmill. Perhaps the ideal employment of a bolter mill is as a complementary unit to a sawmill so that both could produce stock for furniture plants. In such a situation, large, straight, high quality logs could be directed to the sawmill and small, crooked, and defective logs could be sawn in the bolter mill. In this manner, effective utilization could be improved by using the sawmill and bolter to best advantage.

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Discussion

Fred C. Simmons (Northeastern Forest Experiment Station): One ex-

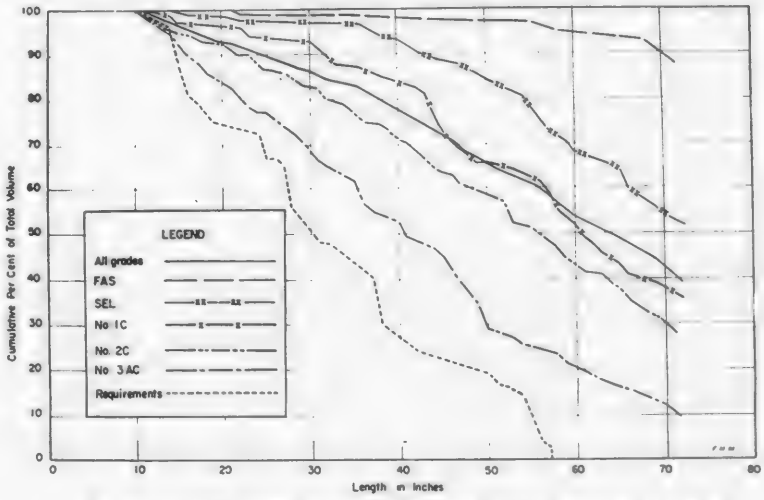

Fig. 4a.—Cutting lengths required by furniture industry compared to cutting lengths yielded by each grade of standard lumber.

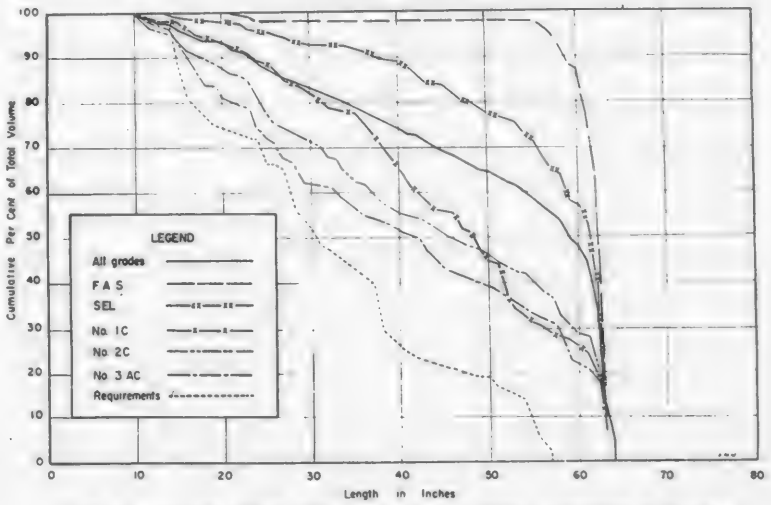

Fig. 4b.—Cutting lengths required by furniture industry compared to cutting lengths yielded by each grade of bolter produced lumber.

ample of successful use of the bolter is a northern New York mill owned by a furniture manufacturer. They have three bolters and a short log standard sawmill. All logs are brought in six feet long. Those less than 17 inches in diameter go to the bolters, larger ones are cut on the conventional mill. On these small logs, the bolter gets up to 20 per cent more volume recovery and much higher grade recovery. Lumber production on a bolter probably averages around 4,000 feet per shift, but I know of installations making 7,000 feet per shift, with two men on the machine.

John B. Veach, Jr. (Bemis Hardwood Lbr. Co.): Is the New York mill using a short-log bolter or gang saw?

Mr. Simmons: They're using the bolter. One important advantage of the bolter is the automatic taper. You are sawing parallel to the bark and the taper comes out of the core. This is especially valuable for species like hard maple and white birch where sapwood is the material sought, but most hardwoods have a lower grade core.

Jack Pfeiffer (Oregon Forest Products Lab): What are the drying problems in short lengths?

Mr. Simmons: When they are dried in steel-strapped and end-coated bundles that are broken up at the planer, there is practically no degrade. This dimension stock is manufactured to length with only a 2-inch trim allowance; thus the end-coating to eliminate seasoning checks. An actual advantage of drying bundled stock is that a greater volume can be handled in the same space because of the absence of overhanging lengths as in standard lumber. Moreover, because this is dimension stock, drying is performed, in effect, only on usable material.

Mr. Pfeiffer: How wide a bundle is used?

Mr. Simmons: 24 by 24. This bolter is being used more and more in the furniture industry. They advance and recede with foot pedals. The rate of advance is 240 ft. per minute and receding is 360 feet per minute. Band bolters have not worked out. The band pushes the bolt down and out and the bolt is not stable on the carriage.

Pulp Chips and Tanbark from Hemlock Slabs by Air-Flotation[1]

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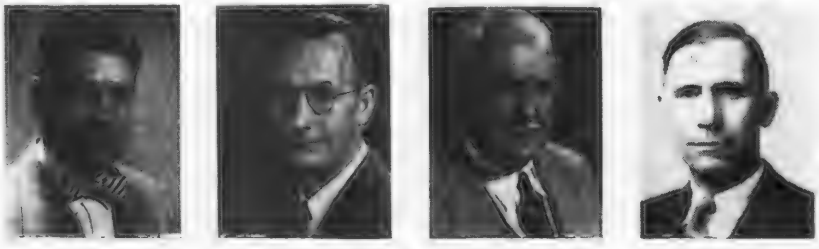

Utilization of hemlock sawmill wastes is of dual interest: as a source of tannin materials and pulp chips. A process has been developed for separating hemlock slabs into a bark fraction suitable for tanning extraction and a wood fraction for pulping. A flow sheet and cost estimate for a proposed plant are presented.

FOR SEVERAL YEARS the U. S. Department of Agriculture has been actively engaged in the development of domestic tanning materials in an attempt to mitigate the almost complete dependence of our heavy leather industry on foreign sources of vegetable tannins (7, 17, 18, 20).[2] At the present time the equivalent of more than 100,000 tons of pure vegetable tanning materials are consumed (18) each year in this country, principally for the manufacture of leather. Only 20 years ago, fully 50% of this consumption was produced from domestic tanning raw materials: chestnut wood, oak bark, and eastern hemlock bark. The chestnut blight rendered commercial chestnut stands virtually extinct (5) while rising labor and transportation charges placed oak and hemlock bark in a less favorable competitive position with foreign tannin sources, resulting in our almost complete dependence on foreign vegetable tannin supplies as both raw and finished extracts.

Concurrently there is a tremendous increase in pulp and paper production which threatens to deplete our forest reserves. It is therefore necessary that we utilize forest resources more effectively. It has been said that we have potentially available, but unused, enough tannin-bearing barks within our borders to supply twice our needs and that there exists as sawmill waste enough wood fiber to supply much of our expanding pulpwood requirements (12). The wastes from some species such as hemlock, oak, Douglas-fir, and Sitka spruce can potentially supply both pulp chips and tanbark.

Recently progress has been made in utilizing heavy sawmill wastes, particularly with large mills of the far west (3) and south (10) which can finance the heavy investment of a saw log debarker. This, however, repre-

[1] Presented by title only at Session III, Logging and Milling, Ninth National Meeting, FPRS, June 21–24, 1955, in Seattle, Wash.

[2] Numbers in parentheses refer to literature cited.

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Edward L. Griffin, Jr. is supervisor of tanning products development unit at the Eastern Utilization Research Branch, where he has carried out pilot plant studies since 1942. He holds B.Chem. and Chem. Eng. degrees from Cornell U.

Clifford S. Redfield, a graduate chemical engineer from M. I. T., is engaged in cost estimating and economic evaluation of processes at the Philadelphia laboratory.

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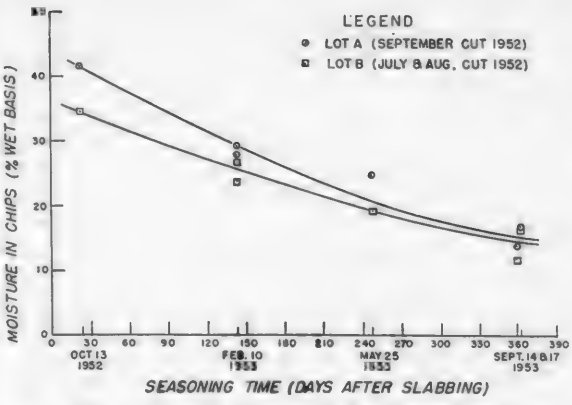

Fig. 1.—Air drying of banded 4-foot hemlock slabs.

Fig. 2.—Experimental Carthage tilted disc portable slab chipper.

sents only a fraction of the total potential in the south, northeast, and midwest where the small sawmills cut most of the lumber (12). Many methods of debarking sawmill wastes have been proposed and used in the past few years. Most are impractical, too expensive, or impair the use of tannin-bearing barks for extract manufacture.

The air-flotation method for the sorting of granular materials, first described by André (2), appears capable of satisfying the physical specifications of both the wood chip and tanbark products, namely, wood chips suitable for pulping and a bark-wood concentrate containing 10% tannin. This method, which depends on specific gravity differences as well as relative size and shape of the particles for efficient segregation (11), has been investigated for the recovery of oak bark from scrub oaks (4, 9), oak slabs and cordwood (21), and for the production of quality pulp chips from unbarked spruce (6).

Preliminary work on this study demonstrating the feasibility of segregating bark and wood chips from well seasoned eastern hemlock slabs and edgings has been reported (16). It remained to determine, however, what production conditions would be most practical, the seasoning time required to satisfy various aspects of the problem, and the production costs.

The development of a successful pulp cleaning device, the centricleaner[3] (15, 22), by the Hammermill Paper Co. and the Howard Smith Paper Mills Ltd. should promote the use of sawmill wastes for pulping by increasing the bark tolerance, and permit commercial sale of chips with a perceptible bark content, even for sulfite pulps.

Process

Seasoned hemlock slabs with attached bark are chipped in a manner effecting a detachment of bark and wood while producing pulp-type chips. The chips are screened into lots of uniform particle size and except for the fines, are segregated by air-flotation into bark and wood chip concentrates. The fines which are high in bark content are added directly to the bark concentrate.

Seasoning: The seasoning of the slabs is necessary for several reasons: seasoning is essential for good separation of the bark and wood during chipping, bark must be seasoned or cured to less than 20% moisture to prevent tannin deterioration by bacterial action during storage and to produce a quality extract.

Thirteen tons of 4-foot hemlock slabs were procured from the Northwoods Timber Co., Baraga, Mich. Two weeks after cutting, the slabs were banded into 400–500 pound bundles and shipped to Carthage, N. Y., for outside storage and periodic chipping tests. Only slabs with attached bark and wood were included for the test. It was estimated that 10 per cent by weight of the waste was bark-free wood which can be processed separately to produce pure wood chips.

The slabs consisted of two lots. Lot A was from trees felled in September 1952 after the close of the peeling season and Lot B was produced from trees felled in July and August 1952 during the peeling season. The banded slabs were stacked in two rows with the top covered by a tarpaulin to keep them free of snow and ice. Fig. 1 shows the rate of drying during one year's storage from the time of slabbing of the logs. It took more than 7 months' seasoning during winter and spring seasons to lower the moisture content of Lot B slabs below 20% and 9–10 months for Lot A.

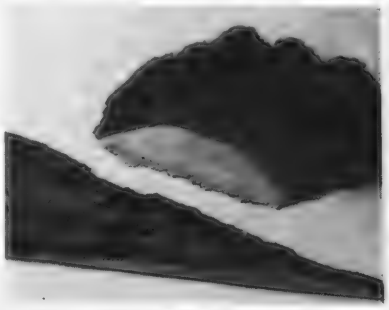

Fig. 3.—Slabs removed from chipper showing chipping action. Above: Tilted disc chipper; below: Vertical disc chipper.

Chipping: In these tests, two models of disc type slab chippers manufactured by the Carthage Machine Co., Carthage, N. Y., were used. Each has a horizontal power feeding device which stabilizes the slabs during chipping to produce chips with a uniform fiber length. The tilted disc model, Fig. 2, is such that the knife enters the bark and then the wood, giving the bark a differential thrust which apparently aids in detaching the bark from the wood. This can be seen in Fig. 3. The top slab shows the type of cutting action obtained with the tilted disc chipper.

In the vertical disc type chipper, lower slab Fig. 3, the knives enter the edge and cut diagonally across the slab, cutting both bark and wood simultaneously with no apparent differential action. Furthermore, this cutting action produced more wood fines and slivers which reduces both the pulp chip yield and the bark content of the fraction through 3-mesh.

The degree of detachment obtained with each chipper on both lots and the relative detachment obtained with respect to seasoning time and moisture content is shown in Table 1. Fig. 4 correlates detachment obtained with moisture content of the chips of both

[3] The mention of commercial products and companies anywhere in this paper does not imply that they are endorsed or recommended by the Department of Agriculture over others of a similar nature not mentioned.

Table 1.—CHIPPING TESTS ON SEASONED HEMLOCK SLABS

Date of Test	Days Seasoned Since Slabbing	Moisture Content When Chipped	Per cent by Weight Attached Bark and Wood			
			Lot A Felled in Sept. 1952		Lot B Felled July–Aug. 1952	
			Tilted Disc Chipper	Vertical Disc Chipper	Tilted Disc Chipper	Vertical Disc Chipper
10/13/52	23	41.6	----	8.8	----	----
10/13/52	23	34.5	----	----		17.9
2/10/53	143	29.2	----	9.5	----	----
2/10/53	143	27.9	6.8	----	----	
2/10/53	143	26.8	----	----		9.5
2/10/53	143	23.9	----	----	1.5	----
5/25/53	247	24.8	2.7			
5/25/53	247	19.2	----	----	1.4	----
9/14/53	359	13.9	----	3.1	----	----
9/14/53	359	11.9	----	----	----	1.95
9/17/53	362	16.4			1.4	
9/17/53	362	16.9	3.1		----	
6/27/54	645	*	----	4.7	----	----
6/27/54	645	*	----	----	----	1.2
			Tilted Disc		Vertical Disc	
2/10/53	One-Year-Old†	20.7	3.2		----	
12/15/52	One-Year-Old†	17.1	----		3.3	
1/ 6/52	Over One-Year-Old‡	10.7	1.0		----	

*Samples not taken at time of chipping—believed to be below 15% moisture.
†Special lot about one-year-old; felling period unknown.
‡Special lot over one-year-old and stored under cover one month before chipping; felling period unknown.

lots immediately after chipping in both chippers. It was estimated that more than 3% by weight of attached bark and wood in the chips would prevent adequate segregation.

For Lot B (July and August 1952 fall), the same detachment was obtained for each of the three tests at 5-, 8- and 12-month seasoning when using the tilted disc chipper. A special lot (of unknown felling period) over one year old and held under cover for one month before chipping also gave excellent results on the tilted disc chipper.

As shown in Fig. 3, it appears that critical conditions exist below which greatly improved detachment was obtained with both chippers. The vertical disc chipper did not give as good results at the lower moisture contents as the tilted disc on Lot B (July and August fall). Both chippers gave equally good detachment on well seasoned Lot A slabs (September fall).

It was concluded in these tests that:

1. A slab chipper with a cutting action which imparts a differential impact force on the bark during chipping would give satisfactory detachment of bark and wood during chipping after only 8 months' seasoning but that a chipper with a less desirable cutting action might give adequate bark and wood separation on well seasoned slabs.

2. A seasoning time of 9–10 months in the open is required during the fall and winter seasons to reduce the moisture content in the bark below the safe storage limit of 20% moisture on the wet basis, although a storage starting during the late spring and summer months may give more rapid drying.

3. On trees felled at the close of the peeling season, a tightening of the bark occurs which makes bark separation more difficult even after a year's seasoning.

A typical screen analysis of the slab chips produced in the tilted disc slab chipper with the knives set to produce a 5/8" fiber length chip is given in Table 2.

Air Flotation: Pilot-plant runs were made on samples of hemlock chips produced at Carthage, N. Y., to determine if segregation results previously reported (16) could be duplicated on slabs of known history under production conditions. In this process, the chips are screened into five fractions: retained on 1-inch, 3/4-inch, 2-mesh, 3-mesh screens, and through a 3-mesh screen respectively. Under production conditions, the + 1" overs would be sent to a rechipper and added to the chip stream to the screens although this was not done in these tests. The three middle fractions were floated separately on a model BX–100 Sutton Steele and Steele specific gravity separator (Fig. 5.)

Each flotation produced a wood fraction, a middle fraction, and a bark fraction. In the double pass process described in a preliminary paper (16), the middling fraction was refloated separately, resulting in secondary wood and bark fractions and a small middling portion. The wood product is made up of the wood fractions from each segregation combined. Similarly, the bark fractions are combined with the through 3-mesh fines to make up the bark product.

Previous results showed that the double pass system could produce a 99% pure wood product and an 80% bark product from well seasoned chips in good yield. Table 3 gives the results of a typical two-pass segregation run on hemlock slabs from trees felled in July and August and seasoned 8 months after slabbing before chipping in a tilted disc forced feed slab chipper. With these less seasoned slabs, it was only practical to produce a wood fraction containing 98% wood, but the bark fraction remained substantially the same, containing 81% bark.

Table 3.—TWO-PASS SEGREGATION OF BARK AND WOOD CHIPS FROM SEASONED HEMLOCK SLABS BY AIR-FLOTATION (RUN 3NH)*

Chips Segregated					Wood Products				Middlings				Bark Products			
Screen Fraction					Chute 1 and 2		Chute 3		Chute 3		Chute 4		Chute 4 and 5		Chute 5	
Through Opening Inches	Retained On Opening Inches	% Retained	% Bark in Fraction	Feed to Separator Pounds	% of Total Chips	Bark Content %	% of Total Chips	Bark Content %	% of Total Chips	Bark Content %	% of Total Chips	Bark Content %	% of Total Chips	Bark Content %	% of Total Chips	Bark Content %
-----	1.000	5.30	19.7	---	---	---	---	---	---	---	---	---	---	---	---	---
1.000	0.645	35.23	33.0	394†	12.63	1.28	----	----	11.01	7.8	----	----	16.89	73.1		
0.645	0.437	27.54	41.0	252	8.59	1.25	----	----	7.89	22.6	----	----	11.06	92.8		
0.437	0.279	13.64	58.9	129	2.35	1.03	----	----	3.77	24.4	----	----	7.52	93.2		
0.279	0.034	15.01	70.9	186												
0.034	-----	3.28	96.4													
Total		100.00	46	961												
					Reflotation of Middlings (Chips from Chute 3 above)											
1.000	0.645	------	7.8	98	3.93	3.10	2.47	5.36	-----	----	4.61	20.2‡	-----	----	----	----
0.645	0.437	------	22.6	69	1.94	3.32	1.96	6.99	-----	----	3.57	33.3	-----	----	0.41	79.2
0.437	0.279	------	24.4	33	0.93	4.48	----	----	2.40	26.5	----	----	0.44	67.9	----	---
0.279 (not floated)			75.4	---	-----	----	----	----	-----	----	----	----	18.29	75.4	---	----
					30.37		4.43		2.40		8.18		54.20		0.41	79.2
Composite Products, % of Feed				Wood:	34.80				Discards: 10.58				Bark:54.61			
Composition of Products					98% Wood				73.9% Wood				81% Bark			

*Lot B Chips, 1.4% attachment.
†Includes fraction retained on 1.00" screen.
‡Consists of Chutes 4 and 5.

Table 2.—TYPICAL SCREEN ANALYSIS OF SLAB CHIPS

Screen Size Through	Over	Retained on Opening	Pounds Retained	% of Total	% Wood
------	1"	1.00"	200.0	6.31	81
1"	¾"	0.645	928.5	29.32	68
¾"	2-mesh	0.437	901.8	28.45	58
2-mesh	3-mesh	0.279	514.5	16.23	45
3-mesh	20-mesh	0.034	510.5	16.11	30
20-mesh	------	------	114.0	3.60	12
Total			3169.3	100.00	54

Fig. 5.—Air-flotation segregation of hemlock slab chips.

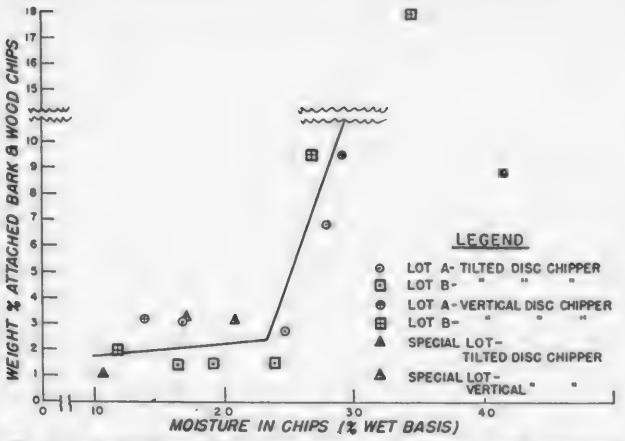
WEIGHT % ATTACHED BARK & WOOD CHIPS
MOISTURE IN CHIPS (% WET BASIS)
LEGEND
LOT A- TILTED DISC CHIPPER
LOT B- " " "
LOT A-VERTICAL DISC CHIPPER
LOT B- " " "
SPECIAL LOT- TILTED DISC CHIPPER
SPECIAL LOT- VERTICAL " "

Fig. 4.—Correlation of the detachment of bark and wood obtained during chipping with moisture content of the chips.

Table 4.—COMPARISON OF SEGREGATION EFFICIENCIES OF HEMLOCK CHIPS CUT FROM SEASONED SLABS IN A TILTED DISC CHIPPER*

Run	2NH†	3NH	5NH	6NH
Months Seasoning as Slabs	Over 1 year	8	12	5
Bark-Free Slabs Removed?	No	Yes	Yes	Yes
Bark Content %	36	46	46	45.5
Attached Bark and Wood % of Total Chips	1.0	1.4	1.4	1.5
Process Used	Two Pass	Two Pass	Two Pass	One Pass
Wood Product % of Feed	51.5	34.0	40	46.5
Composition of Wood Product % Wood	99	98	99	94.5
Bark Product % of Feed	39.7	54.6	50.2	53.1
Composition of Bark Product % Bark	78	81	83	80
Wood in Composite Wood Product % of Total Wood	77	65	72	80
Bark in Composite Bark Product % of Total Bark	92	93	92	94
Discarded % of Feed	8.8	10.6	9.8	0.4
Composition of Discard, % Wood	75.1	73.9	66.2	72.7

*Moisture of chips as floated 10–15% (on the wet basis).
†Reported in reference (16).

An additional run (No. 5NH) was made using the two-pass system on a 3200-pound lot of chips cut in the same chipper from the same lot of slabs, but after 12 months' seasoning. This run was made simulating production conditions. The results are summarized in Table 4 together with the results of other segregations for comparison. Both products were improved, containing 99% wood and 83% bark respectively with a slight decrease in discards.

The feasibility of producing a 95% wood product by using a single pass over the table was also investigated. Tests showed that a 95% wood chip product could be obtained directly with little or no discards while producing an 80% bark concentrate product as before. Results of such a run (No. 6NH) with chips similar to that used in other tests is shown in detail in Table 5 and are compared to the results of 2-pass runs in Table 4.

A 94.5% wood fraction and a 79.8% bark fraction were obtained with very little material discarded. Addition of chips from the bark-free slabs, normally representing 10% of the sawmill waste would yield a wood fraction containing about 95% wood. Thus, it is entirely feasible to use a one-pass system if a 95% wood fraction is acceptable for pulping. A flow diagram illustrating this process is shown in Fig. 6.

The bark and wood content in the slabs will vary markedly from lot to lot and will affect the quantity of each product as shown in Table 4. The efficiency of the segregation process is, therefore, best indicated by the relative amount of bark and wood recovered in the respective products and the amount discarded exclusive of knots which are undesirable in either product.

It is estimated that about 7–8% of the wood portion of hemlock slabs consists of knots which are removed from the wood product during the flotation process.

Evaluation of the Products

Wood Chips: The wood chip product of this segregation process should be an attractive raw material for both sulfite and kraft pulping where recently developed pulp cleaners are used. The almost complete removal of knots from the wood is particularly

Table 5.—SINGLE PASS SEGREGATION OF BARK AND WOOD CHIPS FROM SEASONED HEMLOCK SLABS BY AIR-FLOTATION (RUN 6NH)*

Chips Segregated: Screen Fraction Through Opening Inches	Retained On Opening Inches	% Retained	% Bark In Fraction	Actual Feed to Separator lbs.	Wood Products Chute 1 and 2: % of Total Chips	Wood Products Chute 1 and 2: Bark Content %	Middlings: % of Total Chips	Middlings: Bark Content %	Bark Products Chute 3, 4, 5: % of Total Chips	Bark Products Chute 3, 4, 5: Bark Content %
---	1.00	3.78	18.9	14	unprocessed		----	----	----	----
1.00	0.645	29.50	30.8	111	19.8	6.76	----	----	9.69	80.0
0.645	0.437	29.52	36.7	112	18.0	4.73	0.39†	28.0	11.1	88.8
0.437	0.279	17.04	55.2	74	6.2	5.55	---	---	10.9	83.5
0.279	0.034	17.52	71.2	77	(not floated)				20.2	74.3
0.034	----	2.64	95.0							
Total		100.00	45.5	374	44.0		0.39		51.9	
Possible Recovery by Rechipping + 1" overs‡					2.5		0.02		1.3	
Composite Products					46.5		0.4		53.2	
Composition of Products					94.5% Wood		72.7% Wood		79.8% Bark	

*Lot B chips, 1.5% attachment.
†High concentration of knots removed at Chute 5.
‡Potential recovery by rechipping of +1" fraction based on the distribution of bark and wood obtained for the segregation of —1" fractions.

desirable in sulfite pulping because knots are not pulped by the sulfite liquor and are subsequently removed by the pulp screens. This will at least partly compensate for the loss in yield imposed by the residual bark compared to regular run chips which contain appreciable unpulpable knotty material.

Sulfite test sheets were made to determine the pulping qualities of a 99% and a 95% wood product. The results showed that even the 1% bark content was too high to produce a clean bleachable pulp; but after centricleaning (15, 22), each sample produced a bleached test sheet as strong and clean as sheets from regular run mill-peeled hemlock pulpwood. A normal amount of chlorine was required for bleaching in each case.

The 95% wood product required a somewhat larger discard of pulp screenings than normal while the 99% wood sample lost slightly less material on screening than the normal pulp. The tests indicated a shorter cooking cycle was desirable with these dry chips. (Test chips contained 10% moisture on wet basis). Use of dry chips from sawmill wastes will, therefore, require separate pulping. Since the pulp cleaner will be required in using both 99% wood chips and 95% wood chips, it would not be economical to operate the double flotation process and discard a part of the wood to obtain the higher purity.

Tanbark: The bark concentrate is a good hemlock tanning raw material and compares favorably with the traditional peeled hemlock bark which, years back, was the only tanning material many American tanners used to produce heavy leather. This vegetable tannin is still in demand although high bark handling and bark shipping costs have reduced its use in competition with foreign supplies. The tannin analysis (1) of various bark concentrates produced during these tests averaged about 10% on the moisture-free basis as shown in Table 6. The tannin contents of the pure barks are in the range of 12 to 14% as expected for commercial peeled Michigan hemlock bark (17). The tannin content of hemlock barks, however, varies with locality and age of the tree, location of sample on the tree, and may vary with the seasons (4).

The bark concentrate can be conveniently stored in bins or silos and can be conveyed by the usual methods. This should be a considerable advantage over the present high labor requirements for the handling and storage of peeled bark. Some further comminution of the bark retained on a 0.437" opening (see bark product size distribution, Table 5), may be desirable. The 20% wood portion, although it contributes but little tannin to the sample, does facilitate bark handling by reducing the tendency to pack during extraction (8).

A local tanning extract manufacturer after analyzing a small sample of this bark product considered it an acceptable source of hemlock extract.

Costs

A cost estimate for the production of tanbark and pulp chips from hemlock slabs and edgings by the air-flotation method was made based on the single pass process capable of producing a 95% knot-free wood chip product and an 80% bark concentrate. Inasmuch as the development of pulp

SEGREGATION OF AIR DRIED HEMLOCK SLAB CHIPS

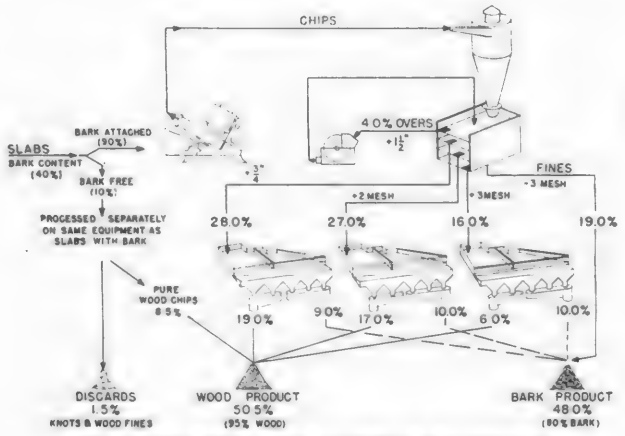

Fig. 6.—Flow sheet for the segregation of hemlock slab chips made from seasoned slabs.

Table 8.—EQUIPMENT SUMMARY

Item No.	Description	Price
1.	Belt conveyor—slab storage to chipper	$16,960.00
2.	Slab chipper—power fed—150 hp.	15,900.00
3.	Cyclone	2,000.00
4.	Hopper	180.00
5.	Vibrating chip screen, enclosed, 60 sq. ft., 2 deck, 1" and ¾" screens	3,940.00
6.	Vibrating chip screens, enclosed, 40 sq. st., 2 deck, 2 and 3 mesh screens	3,170.00
7.	Re-chipper—500 lbs./hr. capacity	700.00
8.	Hoppers—4 required	1,160.00
9.	Hoppers—3 required	950.00
10.	Specific gravity separators—size BXM-200—7 required	14,920.00
11.	Screw conveyors 6"—45'—2 required	2,540.00
12.	Screw conveyors 9"—50'—2 required	3,560.00
13.	Screw conveyors 4"—55'—2 required	2,300.00
14.	Screw conveyor 4"—23'	700.00
15.	Tank—wood 5' diam. x 8' deep	300.00
16.	Screw conveyor 10"—20'	1,000.00
17.	Screw conveyors 14"—22'	1,340.00
18.	Tank—wood 14' diam. x 18' deep	1,860.00
19.	Tank—wood 12' diam. x 18' deep	1,670.00
20.	Screw conveyor 9"—20'	830.00
21.	Tank—wood 12' diam. x 13' deep	1,560.00
22.	Concrete pits for tanks	2,740.00
23.	Pneumatic carloading equipment	2,880.00
		$83,160.00

Table 6.—TANNIN CONTENT OF BARK CONCENTRATES (MOISTURE-FREE BASIS)

Pilot Plant Run	% Bark in Concentrate	Soluble Solids %	Tannin %	Purity (Soluble Solids Basis)
2NH	78	15.59	10.33	66.3
3NH	81	14.24	9.44	66.3
5NH	83	14.97	10.16	67.9
6NH	80	14.24	9.22	64.8

Table 9.—COST SHEET

	Costs		
	Dollars Per Day	Dollars* Per Ton of Tanbark	Dollars Per Ton of Pulp Chips
1. Material—125 tons at $6.00/cord delivered—$5.45/ton	681.25		
2. Credit: 5.26 tons discards at $3.00/ton	—15.78		
Total material cost	665.47	3.661	7.321
3. Labor	240.00	1.320	2.640
4. Total prime cost	905.47	4.981	9.961
5. Indirect Labor			
a. Supervision	37.00	0.204	0.407
b. Watchmen	6.00	0.033	0.066
c. Mechanics	16.00	0.088	0.176
d. Office help	8.00	0.044	0.088
6. Indirect Expense			
a. Insurance, public liability and fire	8.80	0.048	0.097
b. Taxes	17.60	0.097	0.194
c. Interest on fixed capital	44.01	0.242	0.484
d. Depreciation	88.02	0.484	0.968
e. Social Security	4.25	0.023	0.047
f. Workmen's Compensation	3.51	0.019	0.039
g. Unemployment Insurance	17.50	0.096	0.192
h. Vacation time	12.28	0.068	0.135
i. Power	57.59	0.317	0.634
j. Steam (heating)	2.92	0.016	0.032
k. Maintenance repairs and renewals	40.09	0.221	0.441
l. Gasoline	6.25	0.034	0.069
m. Factory supplies	6.01	0.033	0.066
n. Miscellaneous factory expense	10.00	0.055	0.110
7. Total Factory Overhead	385.83	2.122	4.245
8. Factory Cost	1291.30	7.103	14.206
9. Interest on working capital	19.99	0.110	0.220
10. Administration and General Expense	48.47	0.267	0.533
11. Cost to make	1359.76	7.480	14.959
12. Selling Cost	90.89	0.500	1.000
13. Cost to make and sell	1450.65	7.980	15.959

*Assumes value of tanbark to be ½ that of pulp chips. All tons are short tons of 2000 pounds.

cleaning devices has been shown to be capable of cleaning pulps made from chips containing small amounts of bark, it is felt that a wood chip product containing about 5% bark would compare in pulp yield to regular run chips containing about the same amount of knots.

This cost estimate assumes that the slab processing plant is to be a new and independent enterprise, even though, it is realized, it should logically be operated in connection with a pulp mill or, better still, a tannin extraction plant. It is assumed that the proposed slab processing facilities will have a capacity of 125 short tons of slabs per day operating 24 hours per day and 300 days per year. The slabs will be obtained from sawmills in a 100–150-mile radius of the plant. The sawmill will band 4-foot slabs and edging into ¼ to ½-cord bundles and store them in the open for 9–10 months before shipping to the slab segregation plant. It is estimated the slabs will cost $6 per cord delivered and on the basis that one cord of air-dried slabs produces 2,200 pounds of chips, the raw material cost of the chips will be $5.45 per short ton.

A flow sheet of the process, Fig. 6, shows the relative quantities of chips at each stage of the operation while operating on typical slabs. It is assumed that 10% of the slabs and edgings will be bark-free. This portion will be run separately to produce pure knot-free chips upgrading the overall wood product. A yield of 85% of the bark-free slabs is assumed. This is based on a knot content of 7.5% and the production of 7.5% wood fines during chipping. For the normal slabs with attached bark, a 97% yield was assumed for the cost estimate, allowing 3% for losses or discards of small portions as required to maintain the required purity of the products. This gives a production of 62.04 short tons of wood chips, 57.7 short tons of tanbark, and 5.26 tons of discards per day.

Table 7 lists the capital costs for a 125-ton-per-day plant erected in the Upper Peninsula Michigan Area; Table 8 summarizes the equipment required with estimated costs; and Table 9 gives estimates of production costs based on a 300-day year, 24-hour per day operation.

The respective production costs of the tanbark and pulp chips produced are figured on the basis that the pulp chips have twice the market value of the tanbark. Therefore, they must carry the greater part of the costs since the costs solely attributable to the bark fraction are low.

Assuming the pulp chips and tanbark have a sale value of $20 and $10 per short ton f.o.b. plant respectively, the annual net sales would be $534,000, giving a gross annual profit of $147,000 which, after deducting the usual administration, research and selling expense, and income tax, gives a net return of $47,500, or approximately 18% return on the fixed capital investment.

Table 7.—CAPITAL COSTS

Land and site preparation—3 acres	$ 1,500.00
Roads and parking areas	11,800.00
Railroad siding, 1000 ft.	9,000.00
Buildings	41,140.00
Boilers for heating	1,200.00
Equipment—manufacturing	83,160.00
Erection of equipment—manufacturing	20,780.00
Piping and ductwork	5,820.00
Erection of piping and ductwork	3,490.00
Heating—installed	2,330.00
Lighting—installed	1,960.00
Power—installed	8,770.00
Transportation facilities—slab handling	18,000.00
Freight on equipment	1,600.00
Office furniture and fixtures	800.00
Contingencies	26,400.00
Engineering fees	26,400.00
Total fixed capital	$264,150.00
Working capital	$120,000.00
Total capital	$384,150.00

Cost estimates for the 2-pass flotation process which yields a 98–99% wood fraction show this process to be less attractive since this wood product probably could not sell at a sufficient premium over the 95% product to compensate for the lower wood yield obtained and the additional equipment and processing costs entailed in the second flotation.

Conclusion

Under current economic conditions, the utilization of hemlock sawmill wastes in the Upper Peninsula Michigan Area is dependent on the utilization of the bark as well as the wood portion of the slab because the bark represents about 40–50% of the waste. The air-flotation method can be economically operated to produce a pulp chip product which should prove acceptable for sulfite and kraft pulp making provided a market for the bark product can be obtained. This will require the erection of bark extraction facilities in the area. Market surveys have shown there is sufficient demand for hemlock extract to assure the sale of extract produced on this scale. Such an extraction plant would also have available large quantities of peeled hemlock bark produced nearby as a pulpwood byproduct. This extract plant would be in an excellent location to supply tanneries in the Lake States and the midwestern areas.

Acknowledgment

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Young-Growth Douglas-Fir: Is It Predisposed to Warp?[1]

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Large percentages of studs cut from small, young Douglas-fir timber were not degraded because of warp when air seasoned under virtually no restraint. However, the predisposition of the studs to twist markedly when they contained material from close to the centers of logs appears to present a problem. Relationships between magnitude of warp and moisture content were almost linear in the range of 17 to 6 per cent moisture content.

Introduction

DURING THE PAST DECADE, in the Douglas-fir region there have developed in almost mushroom fashion small sawmills of high productivity which specialize in sawing studs. This lumber product is being turned out in enormous quantities to meet post-World War II building needs. It generally is an eight-foot stick, precision trimmed and nominally 2 by 4 inches in dimensions, although 2- by 3-inch studs and lengths somewhat over or under 8 feet are prepared for special orders.

Some mills use anti-stain chemicals when the studs are shipped green. Water-repellent end coatings are applied to smooth-end-trimmed stock at some mills, while at other operations there are kiln- and air-drying facilities to season rough-green studs before they are dressed, trimmed, graded and loaded into cars for shipment.

Sawing equipment of the various stud mills differs greatly. Telford (1) (2)[3] has studied equipment needs and has prepared general guides to skeleton operating costs and to mill productivity where various sawing units are used to manufacture lumber from small logs. Trade journals have described stud mills built in recent years (3).

The mills visited during the present study were of representative types and the majority were cutting only studs from small, young timber. Four exceptions were one tie mill and three mills of conventional design which sawed long timber of the "old-second-growth" type varying in diameter from 12 to about 60 inches. Mills cutting old-growth Douglas-fir, whether or not they cut studs exclusively, were not included in the study.

The Warping Problem

Warping, or deviation from straightness and flatness in lumber, can be a provoking problem to the lumber manufacturer, but it is also a problem to merchandisers and users of lumber. Certain amounts of distortion in lumber can be attributed to inherent characteristics of the material and seem to have been accepted, or perhaps tolerated, by its users for many years. Carpentry skill and wise use of lumber on a building job causes the offending pieces to disappear into the structure in the form of fire stops, cripples, or bracing, and for other purposes where short material can be used effectively. Now and then, however, badly distorted pieces have to be discarded and this practice results in waste. It is not suggested that the situation just described exists extensively. However, it is suggested that there may be problems of this nature and they require study.

Objective and Associated Work

Since attention is being focused on the milling of young-growth Douglas-fir timber into building studs, and since this type of lumber inevitably will be compared with its old-growth counterpart, the Oregon Forest Products Laboratory undertook to survey the nature and extent of a possible warping problem involving this lumber item. The study was designed to measure the predisposition to warp displayed by samples of the output of a number of stud manufacturers scattered throughout western Oregon.

Small-diameter young timber may present problems in warping because of abrupt curvature of the annual growth rings, presence of abnormal tissue such as compression wood, and presence of juvenile wood in the vicinity of the pith.

There have been few previous studies of warping. King's work (4) apparently was in progress at about the time the Oregon study was made, the summer of 1953. Torgeson has presented some information on the warping of hardwood lumber (5). Conversations with lumber association representatives revealed that a number of years ago a study was made of the warping of kiln-dried old-growth Douglas-fir lumber in several sizes and grades. There appears to be no published report of the results of this study, although the conversations mentioned brought out the point that warping, particularly crook, was low in incidence for the type of material studied.

Anderson, Knauss, and Frashour (6), working with ten kiln charges totaling about 65 M board feet, found that planer split and warp, combined, was the most important of a number of degrading factors causing drop in grade during the seasoning and machining of young-growth Douglas-fir 2- by 8-inch common dimension lumber 16 feet long. Number 1 common lumber was down-graded to the extent of 5.7 per cent and Number 2 common lumber 3.8 per cent when kiln schedules calling for a low final relative humidity were used. When schedules requiring higher final relative humidities were used, however, the percentages of degrade because of planer split and warp were only 1.2 and 1.1 per cent, respectively, for the two grades mentioned.

Knotholes, loose knots, and edge knots, combined, became more important as a degrading factor than the planer-split-and-warp difficulty in the Number 1 grade when the high final relative humidities were used. Although warp was not separated from

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[3] Numbers in parentheses refer to literature cited.

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Fig. 1.—A minimum of flatwise restraint provided for air seasoning young-growth Douglas-fir studs by use of a two-section pile. Several twisted pieces can be seen, one in particular in the top course of the lower section.

Fig. 2.—Oblique view of special two-section air-seasoning rack. These randomly selected studs have not been trimmed. 4- by 4-inch lumber was used for pile supports; stickers were surfaced 1- by 4-inch strips.

Fig. 3.—A study pile of air-dried studs being broken down for inspection. Warp measurements were made with reference to the right-angle jig (arrow) on which a stud has been placed. Deviations from the plane surfaces of the jig were measured in sixteenths of an inch.

planer split in this study, it is reasonable to suspect that planer split is caused principally by roll pressure in the planing machine when cupped lumber is being surfaced. Further, it has been indicated by one of the investigators that planer split, rather than various forms of warping as such, was the predominating cause of the drop in grade. Crook, bow, and twist apparently occurred in insignificant amounts.

The study most closely related to the present one is King's, because it involved studding cut from relatively small timber. However, this work was confined to observations of southern pine lumber following its drying and during its storage at a few representative retail lumber yards. Its purpose was to evaluate the effectiveness of certain chemicals and other treatments applied to the lumber to alleviate distortions which might occur because of moisture gain or loss while the lumber was stored.

In contrast, the present study was designed to determine how large an incidence of warping might be expected in studs permitted to air-dry virtually *free of restraint* under weather conditions prevailing in western Oregon during the summertime and to measure the warping magnitudes which occurred. No effort was made to prevent or to control the development of the warp.

Procedure

Field work for the present study was completed during the summer of 1953. The analysis of results and some related studies were carried on during the following year and a half.

Field Procedure: It was planned to permit the green studs to distort as freely as possible and therefore to assume, as they dried, the forms of warping characteristic of the pieces under study. Accordingly, at each mill site the selected sample of lumber was piled for air seasoning with considerable edge space allowed between the sticks in each course. Further, as shown in Figs. 1 and 2, the finished pile had two sections, each section having five courses of ten studs. Each section was independent of the other and thus was provided a minimum of flatwise restraint on the bottom courses of lumber in the pile's sections. Protection from rain and direct sun was afforded the lumber by a roof over the pile constructed of materials available at the mill site.

Approximately 100 8-foot, rough-green studs were randomly selected from 2- by 4-inch lumber at each of 20 western Oregon sawmills, Mill 1, 2, 3, etc. One sample of 99 sticks was selected from green, surfaced material. The majority of these mills were cutting studs exclusively.

The selected green studs were inspected for straightness and rough-graded during the piling operation, and a thin wafer one-half to one inch along the grain of the wood was cut with a portable saw from the end of each stick for determination of ring count and specific gravity.

After they had seasoned, the piles of studs were broken down and measurements were made of the moisture content and magnitude of warping, if any, of each piece. Moisture contents were determined with a resistance-type electric moisture meter fitted with electrodes suitable for use on two-inch lumber. The right-angle jig shown in Fig. 3 was used to facilitate measurements of warp. All deviations from straightness in the lumber were measured in sixteenths of an inch. Bow and crook were measured from the surface of the jig to the warped stud. In the case of twist, the elevation of the fourth corner in the wide face of the stud was measured vertically from the jig's surface; the other three corners of the stud would lie in a plane and hence would be in contact with the flat surface of the jig. As a check on the twist measurements, these deviations were measured at diagonally opposite corners of each twisted stick. Cup was not measured as it was relatively unimportant in this width of stock.

At a few mills with planing facilities, it was possible to follow the rough-dry material through the surfacing operation and to make observations on the amount of planer skip, an indication of dry undersize, and the reduction of warping because of surfacing.

The bulk of each sample of rough, dried studs was returned to the cooperating mill's production without further observation, but 10 to 15 pieces from each mill were brought to

Table 1.—BASIC DATA ON SEASONING AND GROWTH-RING COUNT OF TWENTY LOTS OF YOUNG-GROWTH DOUGLAS-FIR STUDS

Pile	Pieces	Drying time	Moisture content		Pieces with rings per inch of:			Mill type
			Final average	Range	Less than four	Less than five	Five or more	
		days	Per cent*	Per cent*	Per cent†	Per cent†	Per cent†	
1	92	55	15	12–18	10	28	72	Band
2	100	54	16	14–20	4	16	84	Band
3	100	44	13	12–14	1	15	85	Twin circular
4	101	49	15	13–18	0	11	89	Circular
5	100	49	15	12–18	9	32	68	Circular
6	98	48	14	12–18	8	25	75	Twin circular
7	100	46	14	12–16	4	17	83	Twin circular
8	33	43	14	11–16	18	21	79	Band
9	99	43	14	11–17	7	32	68	Band
10	98	42	17	14–24	36	62	38	Circular
11	100	54	17	14–22	5	17	83	Tie
12	94	46	16	12–20	6	26	74	Circular
13‡	99	44	18	16–20	20	37	63	Band
14	80	33	17	14–19	3	8	92	Portable circular
15	100	33	16	15–18	7	40	60	Twin circular
16	100	50	21	18–24	3	22	78	Circular
17	99	30	16	14–17	2	16	84	Twin circular
18	98	29	20	16–22	29	52	48	Circular§
19	99	29	19	16–21	13	28	72	Cant resaw
20	100	43	14	12–16	0	4	96	Circular
Average		43	16		9	26	74	
Range	29–55		13–21		0–36	4–62	38–96	

*Based on oven-dry weight.
†Based on total pieces in lot.
‡Surfaced four sides before seasoning.
§With horizontal band resaw.

the laboratory for additional study. This sub-sample was randomly selected from material accumulated in the field. The retained studs proved useful because they made possible a study under controlled conditions of the relationship of warping to moisture loss.

Related Studies: In a dry kiln, the sub-sample of studs mentioned was stacked in a special rack mounted on kiln cars with the pieces of lumber completely free of restraint. The charge was brought successively into equilibrium at average moisture contents of 16.4, 11.5, and 6.5 per cent. Following each equalization treatment, the magnitudes of warping of the studs were measured by the same procedure as had been used in the field.

The successively diminishing levels of average moisture content were established by maintaining appropriate wet-bulb depressions at dry-bulb temperatures not exceeding 130 degrees F. The charge of studs was conditioned until its constant weight was assured at each moisture content level.

The wafers previously cut from the end of each stud yielded data on annual ring counts and specific gravities of the study pieces. They also were used to classify this material with respect to the approximate position in the cross sections of the logs from which they came. Two types of ring counts were made. One count was made where the rings per inch were expressed in whole numbers to the nearest fully included ring per inch. Wafers from 1893 individual studs were counted, a number of wafers having been discarded because they contained much knotty tissue.

It was desired to attempt a correlation between ring count and specific gravity, and so a second ring count was made on 1590 of the same wafers. Rings per inch were recorded to the nearest 0.1 ring. Specific gravities of these same wafers also were determined. The specific gravities were calculated from weight and volume measurements of the oven-dried wafers.

The study material was sorted into four groups: (1) center cuts (material containing pith, or from close to the center of the log), (2) vertical-grain side cuts, (3) flat-grain side cuts, and (4) miscellaneous cuts such as bastard-sawn and pieces of uncertain origin. The objective of this type of classification was to facilitate the relating of warping to the general character of the material.

Analysis of Warp Measurements: Three types of warp were recognized —crook, bow, and twist—and each was measured in the field. Combinations of warp types were numerous, and it was necessary to express the warp measurements in different ways using various magnitude ranges both for combinations of warp types and for principal or most pronounced warp types.

Essentially, the measurements of warp were sorted into magnitude classes in two different ways for each sample of studs. The percentage incidence of warping by types in each magnitude class was then computed. The first arrangement of magnitude classes was based approximately on limits for crook specified by established grading rules.

The American Lumber Standards (7) and the published rules for grading dimension lumber of coast Douglas-fir (8) and southern yellow pine (9) were consulted. The American Lumber Standards provided a general, but not a definitive, basis for reference; the rules for grading coast Douglas-fir dimension lumber do not contain specifications on the magnitude of crook permitted in the various lumber grades. The southern pine grading rules, however, do provide specifications on the magnitude of crook permitted in 2-inch dimension lumber, and these rules were used as one basis for appraising the results of this study. It was assumed that lumber grading practice with Douglas-fir studs might adhere to the same standards as are indicated for southern pine with regard to crook.

Bow and twist, maximum permitted magnitudes for which are not specified in any of the sources mentioned above, were referenced to the established standards for crook as recorded in the southern pine grading rules.

The second arrangement of warp-magnitude classes was made by selecting arbitrary limits for these classes expressed in sixteenths of an inch. This was done, first, because there appeared to be an absence of written specifications for warp in Douglas-fir and, second, because it made possible a more comprehensive display of data relative to the predisposition to warp evidenced by the studs.

It became apparent during the measuring of warp that distortions of the lumber, particularly by twisting, were associated with the characteristics of the material of the stud, that is, whether the material was from generally near the center or from elsewhere in the logs. An analysis, therefore, was made in which warping magnitudes, especially those for twist, were related to the characteristics of the material comprising the studs. The characteristics included in this analysis were material classification, moisture content, rings per inch, specific gravity, and magnitude of warping.

Results

The results of air seasoning the samples of studs for periods ranging from 29 to 55 days are shown in Table 1. Average moisture contents of the piles of from 13 to 21 per cent were established, the wide variation in final average moisture contents being influenced considerably by the locations of the piles and consequent variation of weather in western Oregon. A number of checks on the distribution of the moisture contents of individual pieces in any particular pile revealed that the majority of the sticks had moisture contents of from 2 to 3 per cent each side of the averages indicated in Table 1. However, the occasional heavy, slow-drying, or high-moisture-content stud had a final moisture content well above the average, and the converse

was true of the light, fast-drying pieces.

In Table 1 also are indicated results of the first ring count, which have been put in the form of a cumulative per cent frequency curve shown in Fig. 4, upper curve. Although there was considerable variation in the rate of growth among the various lots of studs, the curve indicates an average incidence of about 9 per cent for material of less than four rings per inch, which was tabulated as having three rings per inch. Assuming that less than an even four rings per inch is an earmark of "coarse" material, it appears that large volumes of young-growth Douglas-fir with relatively low ring count are not to be expected in the lumber market at the present time.

More refined ring counts (counts to 0.1 ring per inch) were plotted into a cumulative frequency distribution pattern, shown in the lower curve in Fig. 4. It is evident from comparing the two distribution curves shown in this figure that assessing the portion of young-growth Douglas-fir which will fall into any specified ring-per-inch grouping will depend somewhat upon how the ring counts are made.

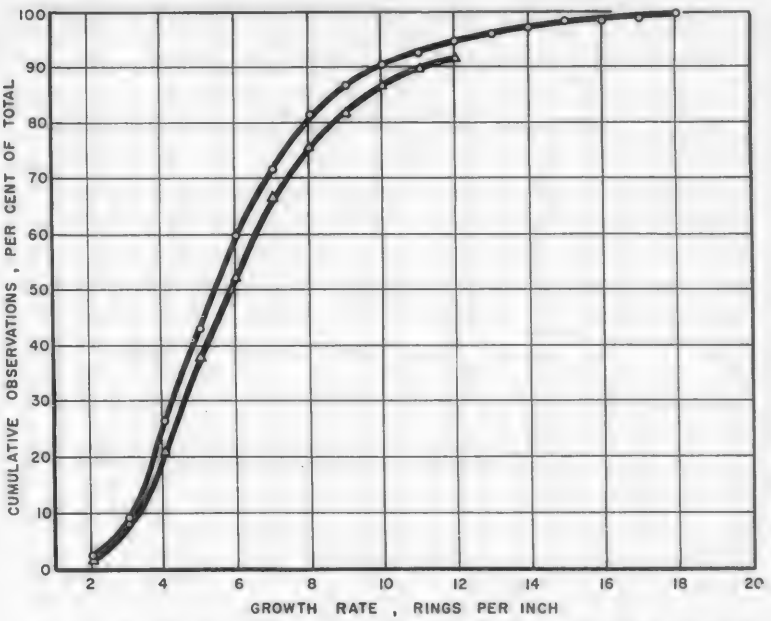

Fig. 4.—Growth rate in rings per inch, shown in cumulative percentages of young-growth Douglas-fir studs examined. Upper curve is based on 1893 ring counts to the nearest full ring included. Lower curve is based on 1590 ring counts to the nearest one-tenth ring.

Specific gravity data were put in the form of a distribution chart, Fig. 5. It should be noted that the specific gravities were based on oven-dry weight and oven-dry volume and hence are higher than when based on oven-dry weight and green volume. The mean specific gravity of the study material was 0.49. The specific gravity would be 0.43 on the green-volume base as determined from the usual adjustment formula. The range in specific gravity for the material studied appears to be in agreement with ranges in specific gravity reported for Douglas-fir in numerous sources. Center-cut pieces averaged 0.45 in specific gravity, and pieces over one inch from the pith had an average specific gravity of 0.50.

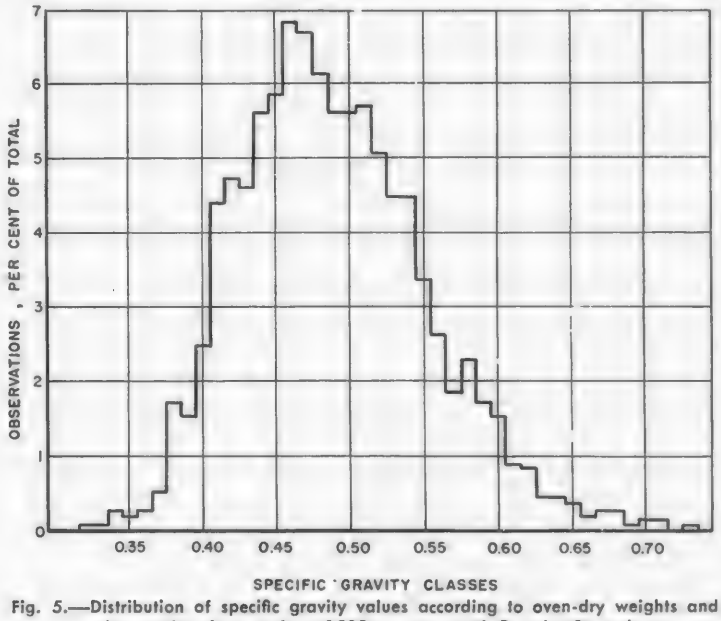

Fig. 5.—Distribution of specific gravity values according to oven-dry weights and volumes of wafers cut from 1590 young-growth Douglas-fir studs.

Attempts to correlate specific gravity with rings per inch were unsuccessful. Plotting of points for numerous sets of specimens resulted in a complete scatter.

A scheme for gauging the incidence of warping determined by this study against established grading standards is illustrated in Table 2. In using the American Lumber Standards for Softwood Lumber (7) as a guide, two difficulties arose. First, the Standards only define the types of warp (except twist, which is not mentioned) and provide names for degrees of warp, such as slight and small, but they do not suggest what degrees of what types of distortion should be associated with various grades of dimension lumber. Apparently, decisions on this matter have been left to the various lumber grading agencies. Second, the Standards' definition for crook (and also for cup) reads such that possibly it has two interpretations relative to determining the exact magnitude which should be associated with the degree stated in the Standards. Therefore, both the "same curvature" concept derived from a literal interpretation of the Standards, and the "proportionate-to-length" concept, which apparently is the understood meaning of the definition for crook, have been used in compiling Table 2, which compares degree of crook with various specific magnitudes of this distortion.

These factors, degree and magnitude, have been tabulated against the incidence percentages of the three types of warp measured in this study. The southern yellow pine lumber grading rules (9), which adhere to the proportionate-to-length concept in specifying limitations for crook, also have been applied in Table 2. The incidences of bow and twist tabulated in the table cannot be compared to written grading specifications because apparently such do not exist, but the importance of these distortions relative to crook can be determined from the table.

Table 2.—INCIDENCE IN EIGHT-FOOT STUDS OF WARP BY TYPES IN VARIOUS MAGNITUDE CLASSES COMPARED TO CROOK SPECIFICATIONS OF THREE LUMBER-GRADING GUIDES

Crook specifications American Lumber Standards†		Southern Pine Grading rules (9) Para 253, 328	Comparable Magnitude Classes	Average incidence of warp in all study pieces*		
"Same Curvature"	"Proportionate to length"			Crook per cent	Bow per cent	Twist per cent
Large	Medium to large	Below No. 3	Over 1 inch	0	0.05	0.65
Medium and Large	Small and greater	Below No. 3	Over ¾ inch	0.05	0.42	2.05
Over Small, including medium	Slight to small	Allowed in No. 3	Over ¼ inch, including ¾ inch	0.26	0.48	6.50
Total incidence over ½ inch				0.31	0.90	8.54
Small (about ⅜ inch)	Slight	To ½ inch in No. 2 To ⅜ inch in No. 1	Over ¼ inch, including ½ inch	4.55‡	5.10	17.80
Total incidence over ¼ inch				4.86	6.00	26.34
Slight	Below slight	Allowed in No. 1	1/16 to ¼ inch	47.03§	47.50	35.80
Total incidence				51.89	53.50	62.14

*Warp types frequently occurred in combination. Here, each type was included separately. See Table 3 for summation by principal types.

†Appendix B of "American Lumber Standards for Softwood Lumber, R16–53" (7), specifies degrees of crook based on 4-inch widths and 16-foot lengths as follows: slight crook, 1 inch; small crook, 1½ inches; medium crook, 3 inches; large crook, over 3 inches. The definition adds: "Shorter or longer pieces may have the same curvature."

‡The incidence of crook over ⅜ inch and including ½ inch was 0.74 per cent, consequently there would be an incidence of 3.81 per cent of pieces crooking over ¼ inch and including ¾ inch.

§The incidence of crook from 1/16 inch to ¾ inch, inclusive, was 50.84 per cent, consequently 1.05 per cent of the pieces crooked over ¾ inch and would have fallen below the grade of No. 1 when judged by standards established for southern pine studs.

Table 3.—INCIDENCE OF WARP IN YOUNG-GROWTH DOUGLAS-FIR STUDS BY TYPE AND BY MAGNITUDE CLASSES

Pile	Magnitude classes; all types warp					Warp by type*			
	A 1/16–3/16 inch	B 4/16–8/16 inch	C 9/16, up inch	B+C	A+B+C	5/16 inch and up			4/16 inch up
						Twist	Bow	Crook	Crook
	Per cent (Basis: pieces in pile)								
1	19	42	10	52	71	28	4	7	24
2	46	26	1	27	73	9	1	9	13
3	16	58	22	80	96	66	3	3	5
4	29	44	14	58	87	35	7	4	14
5	41	38	8	46	87	27	2	5	11
6	18	49	28	77	95	44	8	6	13
7	23	48	27	75	98	51	12	1	11
8	39	27	21	48	87	36	0	6	15
9	43	39	7	46	89	24	2	2	4
10	53	28	1	29	82	13	4	3	8
11	66	24	3	27	93	9	5	2	6
12	54	33	2	35	89	15	2	5	14
13	60	19	0	19	79	2	0	7	11
14	24	64	12	76	100	44	4	5	25
15	30	50	18	68	98	46	6	0	8
16	53	10	0	10	63	1	0	0	0
17	29	52	13	65	94	39	4	3	11
18	57	24	1	25	82	8	2	2	8
19	64	8	2	10	74	6	0	0	2
20	36	42	19	61	97	46	1	0	4
Avg.	40	36	11	47	87	28	3	4	11
Range	16–66	8–64	0–28	10–77	63–100	1–66	0–12	0–9	0–25

*Most severe type when in pieces with a combination of types.

Table 4.—CLASSIFICATION ACCORDING TO POSITION IN LOG OF YOUNG-GROWTH DOUGLAS-FIR STUDS

Pile	Center cuts*	Side cuts		
		Vertical grain	Flat grain	Miscellaneous†
	Per cent (Basis: pieces in pile)			
1	11	10	47	32
2	0	9	41	50
3	84	0	16	0
4	25	11	26	38
5	13	13	30	44
6	39	9	37	15
7	37	0	56	7
8	15	12	20	53
9	12	19	36	23
10	12	27	18	43
11	12	10	44	34
12	27	9	34	30
13	10	16	22	52
14	59	6	10	25
15	45	0	49	6
16	16	2	58	24
17	42	15	18	25
18	34	11	37	18
19	18	18	32	32
20	28	14	38	20
Avg.	27	11	33	29
Range	0–84	0–27	10–58	0–53

*Containing wood within one inch of center.

†All pieces not classifiable otherwise, such as bastard cuts.

Data in Table 2 reveal that the incidence of crook is relatively small in magnitudes sufficiently great to degrade much lumber if the lumber is graded according to rules applied to southern yellow pine. The incidence of twist is considerably higher than the incidences of either crook or bow at all levels of magnitude.

A general summary of the warping is presented in Table 3, where magnitude ranges for warp somewhat different from those used in Table 2 have been established. The variations among samples were quite pronounced. The average incidence in the higher magnitudes of crook and bow was relatively low, where the principal types of warp were tabulated separately, but the percentage incidence of twist in all but one lot was larger than the percentages of crook and bow. When all magnitudes of all types of warp were taken into consideration, the high average incidence of 87 per cent was recorded. The bulk of this figure, however, consists of high incidences of low-magnitude bow and crook, and relatively low-magnitude twist.

A classification of studs by position in the log is shown in Table 4.

Warp incidence and other pertinent data are brought together under three groups in Table 5, the groups consisting of samples of similar character relative to their content of pieces containing center-cut material. Caution should be exercised in putting too much emphasis on the sample included in the group having the highest percentage of center cuts, because it was only one sample (100 pieces). The studs in this lot of material twisted in spectacular fashion, as the data of Table 5 indicate. However, the average moisture content of these sticks was somewhat lower than that of the other samples.

Warping Related to Moisture Loss: The results of equalizing unrestrained studs at three levels of moisture content and measuring the magnitudes of warp that occurred are shown in Table 6. The average magnitudes from this table have been plotted in Fig. 6, from which it appears that the relationship of warp to moisture content was generally linear. The 337 pieces of lumber involved in this study were not green initially but were part of the air-dry stock from the main experiment. Their average moisture content prior to conditioning was about 16 per cent. The conditioning brought almost all pieces to the stated average, plus or minus about 1 per cent.

The results illustrated in Fig. 6 indicate that crook was the type of warp least sensitive to moisture changes, whereas twist was the most sensitive. Twist of center-cut material increased markedly in magnitude with moisture loss, being on the average a little over one-half inch at about 12 per cent moisture content.

Data in Table 6 demonstrate that, even under the accurate moisture-content control achieved in a dry kiln, there was a wide range of magnitude of each type of warp at each level of moisture content. A special study of the variation of individual magnitudes of twist at the three moisture-content levels revealed no apparent reason for these great differences, even among pieces of similar weight, rate of growth, and sources with respect to location in the logs.

Specific gravity, which is known to influence shrinkage and consequently might be presumed to influence distortion of material predisposed to twist, did not serve to explain the wide variation of twist occurring in center-cut material when its moisture content was equalized carefully. Only a limited examination was made of this peculiar

variation, however, and it should be studied in more detail.

Miscellaneous Observations: The results of weighing, both before and after they were surfaced-four-sides, a number of studs air-dried to moisture contents of 14 to 15 per cent indicated that rough-dry studs weighed about 2,250 pounds and surfaced-dry studs weighed about 1,930 pounds per M board feet. Perhaps because of the much smaller volume of material weighed in the present study compared to that weighed in a previous study of young-growth Douglas-fir (6), the weights per M board feet quoted above are somewhat lower than those determined by the previous study: 2,060 pounds per M board feet for S4S material averaging 15 per cent moisture content. It is possible, too, that the average specific gravity of the weighed studs was somewhat lower than that of the dimension lumber used in the previous study, although the average specific gravities of material used in the separate experiments were almost identical.

Observations of machining a limited number of lots, and portions of lots, of the studs revealed that some low-magnitude warp was eliminated during the surfacing of the stock. Not enough measurements were made to provide data confirming an exact figure for the amount of relief to be expected, but it was learned through discussions with planer operators that care in feeding distorted material into the planing machines could help to plane out a limited amount of distortion.

Sniped ends of the lumber occurred when badly twisted material of about 14 per cent moisture content was run through a planer. Where sniping happened, the grader considered the difficulty sufficiently serious to degrade a large number of pieces from Number 1 to Number 3. At this same operation, the grader did not view occasional machining skips as serious enough to reduce grade. This observation was interesting because, at the particular plant in question, the rough-green material had been sawed nearly one-quarter inch under nominal dimensions in both thickness and width, yet the material had seasoned to dimensions adequate to permit almost perfectly clean surfacing.

Some green studs were selected and piled because they displayed pronounced distortion when direct from the saw, the distortions presumably caused by stresses relieved during sawing. Some of these pieces were piled so that gravity favored further distortion and others were piled for the reverse effect. The results were erratic. As they dried, many distorted pieces straightened, irrespective of how they were supported; other pieces continued to distort as they dried. No definite results can be reported on this matter for Douglas-fir studs, but it should be noted that King found that piling southern yellow pine studs on edge, thus favoring reduction of potential crook, resulted in some small degree of success (4).

Compression wood, detected without the aid of anatomical confirmation, appeared in 0.9 per cent of all studs studied. The low incidence of compression wood was somewhat surprising because this tissue, which has abnormal longitudinal shrinkage, often will be the cause of warping. Apparently, however, the young-growth Douglas-fir examined was relatively free of this type of growth, and additional reasons must be found to explain warping (twist in particular) in this species.

Lastly, at two widely separated mills small logs were observed having scattered white speck in the heartwood.

Table 5.—RELATIONSHIP OF WARP INCIDENCE TO PROPORTION OF CENTER-CUT PIECES IN YOUNG-GROWTH DOUGLAS-FIR STUDS

Item	Proportion of center-cut pieces			Weighted average
	0–20%	21–60%	61% up	
Number of piles	10	9	1	--
Avg. moisture content	17	16	13	16
Pieces with 1.0–3.9 rings per inch (Table 1)*	13	6	1	9
Pieces with 1.0–4.9 rings per inch (Table 1)*	30	22	15	26
Center-cut pieces (Table 5)*	12	37	84	27
Pieces twisting 5/16 inch and up (Table 3)*	16	36	66	28
Pieces warped 4/16 inch or more (Table 3)*†	31	60	80	47
Pieces crooked 4/16 inch or more (Table 3)*	10	12	5	11

*Average percentage based on pieces in pile.
†The sums of magnitude classes B and C from Table 3 were large primarily because they included high percentages of twist and lesser percentages of bow and crook of about 4/16 inch magnitude.

Table 6.—WARP MAGNITUDES OF 337 YOUNG-GROWTH DOUGLAS-FIR STUDS AT THREE MOISTURE CONTENT LEVELS*

Warp type	Warp magnitude at moisture content of:					
	16.4%		11.5%		6.5%	
	Avg.	Range	Avg.	Range	Avg.	Range
	Sixteenths of an inch					
Crook, all pieces	1½	1 - 2	2	1 - 3	2½	1½- 4
Bow, all pieces	1½	0 - 3	2½	½- 4	3½	1 - 7
Twist, all pieces	2½	1 - 5½	5½	2 -10½	7½	3 -14
Twist, center-cut piece	4½	½-10½	9	1½-14½	12	2½-19
Twist, side-cut pieces	2	1 - 4½	4	2 - 9	6	3 -11½

*Of the studs, 27 per cent were center-cut with an average specific gravity of 0.46; the balance were side-cut pieces with average specific gravity of 0.49. The average specific gravity of all pieces was 0.48.

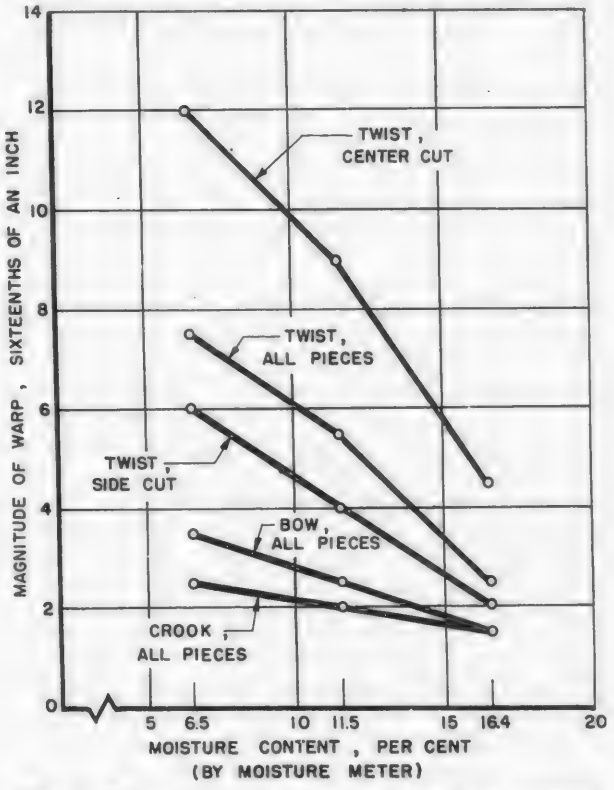

Fig. 6.—Relationship of warp to moisture content after controlled conditioning of young-growth Douglas-fir studs.

This finding indicated that the red-ring rot, *Fomes pini,* generally considered to be a common defect of over-mature Douglas-fir, was at work in quite young timber. The rot has been observed in young Douglas-fir on a number of occasions by various investigators, but it was nevertheless alarming in the present study to see an abundance of material bearing white speck at two mills.

Conclusion

The principal conclusion of this study is that the degrade potential from predisposition to warp of virtually unrestrained young-growth Douglas-fir studs is relatively small. Seasoning restrained studs according to the normal practice should result in much less warping than this study revealed.

The absence of written specifications regarding warp, except for southern yellow pine products, makes difficult a qualitative judgment of the results obtained in the present study. Assuming, however, that the standards for southern pine dimension lumber might be applicable to Douglas-fir dimension lumber, the average potential incidence of degrading amounts of warp in studs manufactured from young-growth Douglas-fir timber appears to be low.

It is strikingly evident, however, that young-growth Douglas-fir lumber products consisting of heart-center material have a predilection to twist; it is thought that in numerous cases the twist would depreciate the grade, appearance, usefulness, and marketability of these products. There is no doubt that seasoning under restraint would correct, or considerably reduce, much of the twist in heart-center material. However, restraint applied during seasoning is likely to cause stress relief of twistable material in the form of splits and seasoning checks, particularly where the material is dried to the lower levels of moisture content. Therefore, potential twist of young-growth Douglas-fir lumber products should be examined critically with a view toward developing practical corrective measures which can be applied by the ever-expanding young-growth fir log-conversion industries.

The Douglas-fir dimension lumber products the consumer expects are the type of products he has been amply supplied in the past and is now being supplied in considerable volume. The supplementary dimension lumber production from young timber now reaching the market should be made comparable, and superior if possible, in all respects to its companion products from the same species. This requirement may make necessary paying more attention to warping than has been needed in the past and to its elimination as a characteristic of lumber.

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Discussion

John Reno (Pacific Lumber Co.): What is the incidence of warp of second growth compared to old growth?

Mr. Snodgrass: This study was not planned to develop a comparison between warping in young- and old-growth material, though such a study should be useful in pointing up specific problems involving warping. Because of the high incidence of lumber cut from small logs which will contain wood from near the center of the logs, and because this center-cut material definitely has a predisposition to twist, it seems reasonable to suppose that the so-called second-growth material would have more tendency to warp than old-growth material, if the comparison were made on the basis of random selection of lumber from a sawmill output where the two types of logs were being processed. It should be pointed out, however, that much of the warping observed in the studs may not have reduced this lumber's usefulness for its intended purpose. The warping may be generally undesirable from an appearance and public relations point of view, though, and means should be devised to keep it to a minimum.

W. C. Fountain (Forest Products Laboratories of Canada): Please restate the relationship of twisting to moisture content.

Mr. Snodgrass: The magnitude of twist increased more than crook or bow relative to moisture loss through the range of moisture content used in the study, approximately 16 to 6 per cent, oven-dry weight basis. Twist in center-cut pieces was greater than in side-cut pieces at all levels of moisture content over the range studied.

H. H. Smith (California Forest & Range Exp. Sta.): What per cent of total stud production is dried before machining?

Mr. Snodgrass: I know of only a few operations where studs are dried, and I don't recall offhand of ever seeing a mill which was cutting studs exclusively from young-growth stock and seasoning its finished stock. I think there are instances where there would be an advantage to do so.

Swelling of Wood and Fiberboards in Liquid Ammonia[1]

ALFRED J. STAMM

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Study was made to determine if wood or fiberboards would be suitable insulating containers for storage of liquid ammonia. Because of the prohibitive degree of collapse on drying after soaking in liquid ammonia, unlined wooden tanks were found unsuitable. When lined with light rubber dam, the penetration of liquid ammonia is small enough so that swelling and subsequent collapse on drying are not serious.

Introduction

THE STORAGE AND SHIPMENT of liquid ammonia has become an important problem since its large-scale industrial use as a fertilizer has been assured (5).[3] The question has been raised as to whether wood or fiberboards would be suitable insulating containers for liquid ammonia. Because of its many water-like properties, it was feared that liquid ammonia would swell all cellulosic materials to a high degree. This research was hence undertaken to answer this question of swelling, as it appears to be the chief stumbling block in the possible use of wood in this way. The data should also be of considerable theoretical value in gaining a better understanding of the shrinking and swelling of wood.

Wood swells to a high degree in polar liquids, like water, with chemically active groups (8, 17). It exhibits only a small to negligible swelling in nonpolar liquids, such as hydrocarbon oils (17). Few pure liquids swell dry wood as much as it is swollen by water (8, 17). Exceptions are formic acid, formamide, certain amines such as n-butylamine, and pyridine and related compounds. With the exception of formic acid, these liquids all contain active nitrogen. All of them show a strong tendency for hydrogen bonding (3). In fact, this property is the best-known criterion for estimating the extent of swelling of wood in various liquids (20). The strong tendency of liquid ammonia to form hydrogen bonds leads to the prediction that it would swell wood to a high degree.

Concentrated aqueous solutions of many highly water-soluble chemicals swell wood more than water does (17). Concentrated solutions of hydroxides of the alkalies (9, 10, 12), salts, such as alkali thiocynates and zinc chloride (14), phenols (17), and certain liquids, which by themselves are strong swelling agents for wood, swell wood more than it is swollen by water alone.

The shrinking and swelling of wood resulting from the loss or gain of liquid water or water vapor is usually between one and a half to three times as great in the tangential as in the radial direction (4). This ratio for any particular wood remains quite constant for various losses or gains of moisture. Practically the same ratio of tangential to radial swelling also persists for swelling in liquids that swell wood less than it is swollen in water.

When wood shrinks or swells from a loss or gain of moisture, the fiber cavities do not change significantly in dimensions (1, 13, 15) except under collapse conditions. The same is true for swelling and shrinking in other liquids that swell wood less than it is swollen by water. However, when the external swelling is greater than that in water, there is always some internal swelling that causes a decrease in the diameter of the fiber cavities. In concentrated aqueous sodium hydroxide, this internal swelling is so great that the fiber cavities are practically closed (9, 12).

If the wood-water system were an unrestrained gel, like a disc of gelatin, a hole cut in the center would change in dimensions on loss and gain of moisture the same as the disc cut from the hole (19). If wood swelled in this way, it would swell the same amount, regardless of the specific gravity. Wood, however, swells more the higher the specific gravity (18).

The fiber cavities are restrained from changing in dimensions when water is taken up or lost by external and internal fibril wrappings oriented approximately at right angles to the fibers (9, 10). Since the wood fibers were originally layed down from aqueous solution, these restraining bands become taut when swelling in water is complete. If the swelling agent tends to swell the fibers still more, the taut external fibril bands make subsequent swelling occur into the fiber cavities (9, 10). The stresses that accompany internal swelling finally stretch or break the external restraining bands so that further external swelling can occur. This is probably the reason why external swelling beyond that which takes place in water is always accompanied by some internal swelling.

When wood swells beyond its water-swollen size, the approximately constant ratio of tangential to radial swelling no longer exists. By some as yet unsettled mechanism, restraint to tangential swelling is considerably less than the restraint to radial swelling (2, 6, 7, 11), so most of the subsequent external swelling is in the tangential direction.

Rate of Swelling

Measurements were made of the rate of swelling of Sitka spruce, redwood, and Douglas-fir in both water and liquid ammonia. Cross sections 1/8 inch thick in the fiber direction with the annual rings parallel to two opposite edges were used for the measurements. Half of the specimens were 2 inches long in the tangential direction by 0.5 inch wide, and half were 2 inches in the radial direction by 0.5 inch wide. Thin cross sections were chosen because matching is more per-

[1] A contributed paper.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Numbers in parentheses refer to literature cited.

The Author: Alfred J. Stamm, a graduate of the California Institute of Technology, Pasadena, taught chemistry at the U. of Wisconsin from 1922–25 while studying there for his M.S. and Ph.D. degrees in physical chemistry. Since joining the U. S. Forest Products Laboratory in 1925, Dr. Stamm has received international recognition for his work in colloid and physical chemistry. He has conducted productive research in capillary structure of wood, electric properties of wood, wood moisture relations, and development of Impreg, Compreg, and Staypak. At present Dr. Stamm is in Australia on a 1-year Fulbright grant, doing research at the Commonwealth Scientific and Industrial Research Organization, Melbourne.

fect in this direction and because swelling is faster.

Stainless steel hemispheres with needle points mounted in the center of the flat face were turned to just fit into the bottom of test tubes with a 1-inch inside diameter. Oven-dried specimens (dried overnight at 110° C.) were mounted vertically in the tubes by pressing them down on the needle points until they were flush with the face of the hemisphere. A dial thickness gage was mounted on the top end of the specimen, the reading was recorded, and then either water at 25° C. or liquid ammonia at about —36° C. was rapidly poured into the tube and the swelling measured as a function of time. In cooling the tube and the specimen, the liquid ammonia boiled momentarily. The swelling measurements were hence made close to the boiling point (—33° C.).

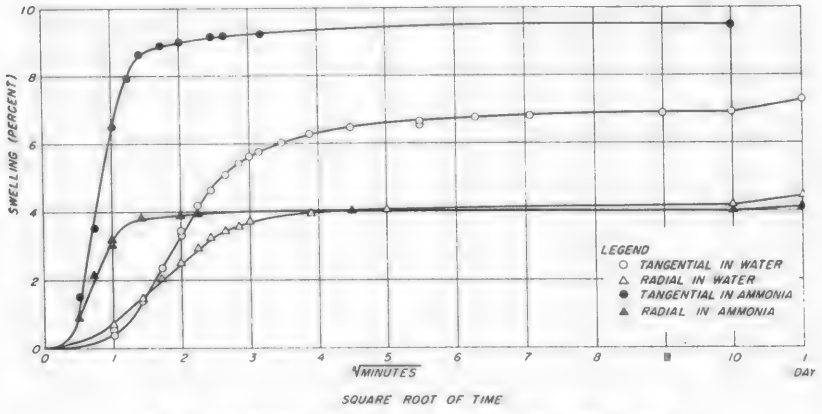

Fig. 1.—Rate of swelling of Sitka spruce cross sections in water at 25° C. and liquid ammonia at —33° C.

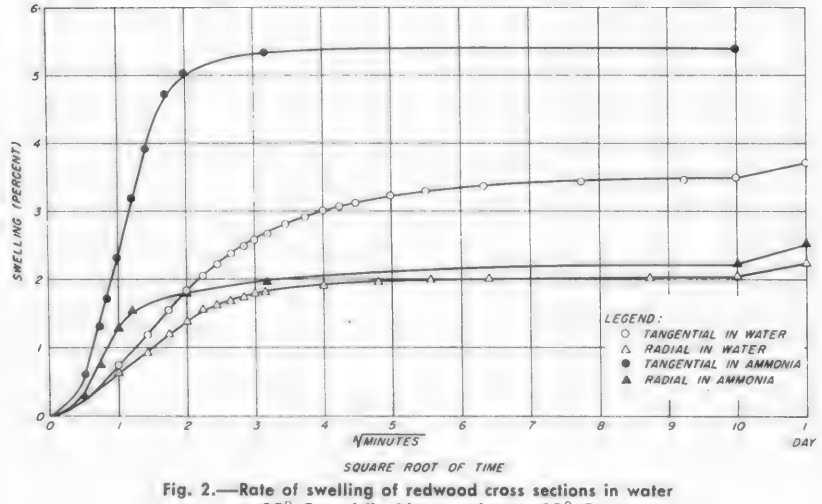

Fig. 2.—Rate of swelling of redwood cross sections in water at 25° C. and liquid ammonia at—33° C.

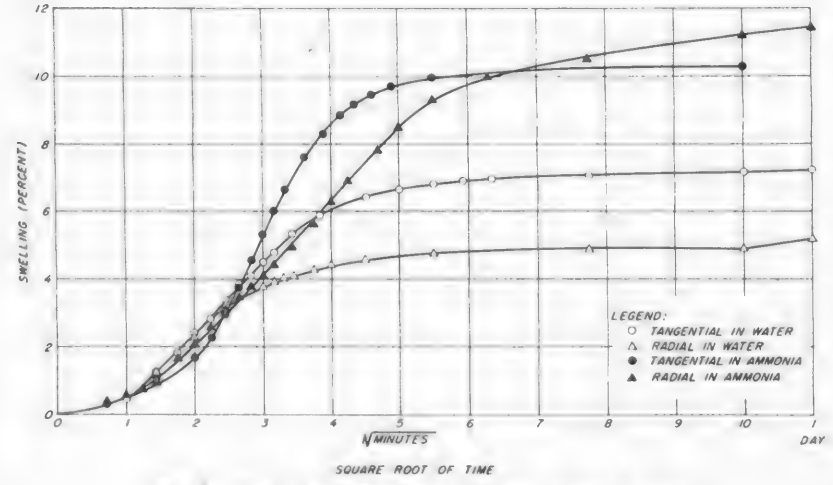

Fig. 3.—Rate of swelling of Douglas-fir cross sections in water at 25° C. and liquid ammonia at—33° C.

Figs. 1, 2, and 3 give the swelling in both the tangential and the radial directions in water and liquid ammonia as a function of the square root of time. The square root of time has previously been shown to give a linear relationship with weight gain up to about 20 per cent weight increase (16). The data show that swelling exhibits an initial time lag behind liquid absorption followed by a linear relationship up to about two-thirds of the final swelling (16).

The rate of swelling over the linear portion of the plots, in all cases, is considerably greater in liquid ammonia than in water. This would be expected since the measurements in liquid ammonia were made much nearer to the boiling point than those in water. It has been shown that the rate of swelling in water increases considerably with an increase in temperature, being about proportional to the vapor pressure of water (16).

Equilibrium Swelling and Collapse on Drying

Similar specimens of the three softwoods, balsa, and specimens of a typical insulating board and typical untempered and tempered hardboard, were oven-dried at 110° C. overnight, measured, soaked in water overnight, measured, and then air dried, oven-dried, and again measured. Table 1 gives the dimensional and volumetric swelling together with the collapse that occurs upon redrying (decrease in dimensions below the original oven-dry dimensions). The four species of wood showed virtually no collapse. The fiberboards showed an appreciable recovery in thickness (negative collapse), but little collapse in the sheet directions. This is characteristic of all fiberboards.

Table 2 gives similar data for swelling in liquid ammonia at about —36° C. Eight-hour and 6-day soaking values were the same within experimental error. The equilibrium swelling of the three softwoods in the tangential direction was 30 to 45 per cent greater in liquid ammonia than in water. The radial swelling for the Sitka spruce and the redwood was nearly the same as in water, as was previously shown to be the case for swelling in aqueous sodium hydroxide. Douglas-fir, however, showed abnormally high radial swelling that even exceeded the tangential swelling. No explanation for this has as yet been found. Balsa,

Table 1.—PROPERTIES OF THIN CROSS SECTIONS OF WOOD AND OF FIBERBOARDS SOAKED IN WATER AT 25° C.

Species	Approximate thickness In.	Specific gravity†	Swelling‡			Collapse§		
			Tangential Per cent	Radial Per cent	Volumetric Per cent	Tangential Per cent	Radial Per cent	Volumetric Per cent
Sitka spruce	0.125	0.417	7.17	4.48	11.65	1.0	0.4	1.4
			7.38					
Douglas-fir	.125	.538	7.23	5.23	12.46	.8	.2	1.0
Redwood	.125	.433	3.75	2.25	6.00	.2	—.2	.0
			3.75	2.26				
Balsa	.125	.089	5.85	1.78	7.63	1.2	.5	1.7
			Length	Width	Thickness	Length	Width	Thickness
Insulite	.50	.292	0.71	1.00	17.7	19.9	0.54	0.54	—5.5	—4.3
Masonite	.25	.903	.88	1.20	20.4	22.7	.35	.40	—8.8	—7.6
Masonite (tempered)	.25	1.096	.66	1.20	18.6	20.3	.59	.66	—9.1	—8.1

*All heartwood.
†Based on oven-dry weight and volume.
‡Twenty-four-hour soak of oven-dry specimens.
§After air-drying and oven-drying at 110° C.

Table 2.—PROPERTIES OF THIN CROSS SECTIONS OF WOOD AND OF FIBERBOARDS SOAKED IN LIQUID AMMONIA AT —36° C.

Species*	Oven-dry specimens						Specimens at 12 per cent moisture content					
	Swelling†			Collapse‡			Swelling§			Collapse‖		
	Tangential Per cent	Radial Per cent	Volumetric Per cent	Tangential Per cent	Radial Per cent	Volumetric Per cent	Tangential Per cent	Eadial Per cent	Volumetric Per cent	Tangential Per cent	Radial Per cent	Volumetric Per cent
Sitka spruce	9.50	4.06	13.56	20.7	20.5	31.3	5.36	2.17	7.35	19.3	18.2	33.8
	9.61	3.96	13.57	21.9	19.8	31.4						
Douglas-fir	10.30	11.45	21.75	16.6	10.6	25.4	5.92	7.82	13.84	18.8	11.6	27.4
	10.20	11.27	21.47	16.5	10.0	24.9						
Redwood	5.32	2.52	7.84	8.3	8.7	16.4	3.63	1.38	5.01	10.8	8.2	17.9
	5.37	2.59	7.96	9.2	17.2							
Balsa	4.33	—2.72	1.61	58.5	17.5	66.0	4.10	1.83	2.27	57.9	18.7	65.8
	4.23	—2.84	1.39	57.8	20.0	66.3						
	Length	Width	Thickness		Length	Width	Thickness					
Insulite	—1.9	—2.2	31.3	27.2	3.3	3.3	3.4	10.0				
Masonite	.8	2.1	144.0	137.0	3.3	4.1	—64.7	—53.0				
Masonite (tempered)	— .3	— .9	161.0	162.0	3.8	4.2	—68.7	—55.5				

*All heartwood.
†Sixteen-hour soak of oven-dry specimens.
‡After air-drying and oven-drying at 110° C.
§Sixteen-hour soak of specimens conditioned to 12 per cent moisture content.
‖After air-drying and oven-drying at 110° C.

surprisingly, swelled less tangentially in liquid ammonia than in water, and actually shrank radially. This will be referred to again later.

Data are also given in Table 2 for the swelling in liquid ammonia of wood specimens preconditioned to 12 per cent moisture content. In all cases the dimension change was less than when dry wood was swollen in liquid ammonia. This would be expected, because 40 per cent of the possible external swelling in water had already occurred.

The fiberboards all shrank slightly in the sheet directions upon swelling in liquid ammonia. The swelling in the thickness direction was, however, so large that the volumetric swelling of the insulating board was 36 per cent greater in liquid ammonia than in water. The volumetric swelling of the hardboards was 6 to 8 times as great in liquid ammonia as in water, chiefly because of the great increase in thickness.

Specimens of wood that were dried after soaking in liquid ammonia collapsed badly, in contrast to the water-soaked specimens that hardly collapsed at all. The collapse of the balsa specimens was so great that they were reduced to ⅓ of their original volume. Fig. 4 shows reflectance photomicrographs of the balsa before and after collapse. The collapsed specimen shows a large amount of cell wall buckling. It is of interest that microtome cross sections of the balsa 10 to 15 microns thick, after soaking in liquid ammonia, did not collapse on drying, as indicated by microscopic observation. These findings are in keeping with the Tiemann hypothesis for collapse (21).

Even though the cross sections of the original specimens were thin, they exceeded the average fiber length of balsa severalfold. Liquid could thus be trapped in filled fiber cavities. If the interfiber communicating pit membrane pores are quite small, evaporation from them may create a tensile force exceeding the compressive strength of the fibers. The microtome cross sections, on the other hand, were so thin that all fibers were cut across at least once. In this case, there was no capillary resistance to evaporation to overcome.

Evidently ammonia is a far more effective plasticizing agent for wood than water is. Collapse can therefore occur as a result of evaporation from pit membrane pores, since less force is needed to cause collapse.

Cross sections of balsa suspended over liquid ammonia in a thermos bottle for a day swelled appreciably, but practically no collapse occurred on drying. This is due to the fact that none of the fiber cavities were filled with condensed ammonia. Enough air evidently remained in each fiber cavity so that its expansion on drying prevented a tension from being set up within the contained liquid.

The fact that balsa is highly plasticized by liquid ammonia is a good indication that the wood becomes highly swollen. There must, therefore, be a large internal swelling, which would cause a substantial decrease in the diameter of the fiber cavities, to offset the fact that external swelling is small.

The insulating board soaked in liquid ammonia collapsed slightly in all directions on drying. The hardboard collapsed slightly in the sheet directions, but showed a large recovery in the thickness direction.

A simple experiment was carried out to find out if wood storage tanks with low permeability liners could be used to store liquid ammonia. Dry balsa specimens were placed in a thermos bottle, and a lightweight rubber dam bag was inserted through the opening and fastened with a rubber band securely to the neck of the bottle so as to seal the balsa specimens between the bag and the bottle. The bag was then filled with liquid ammonia so as to press against the balsa specimens.

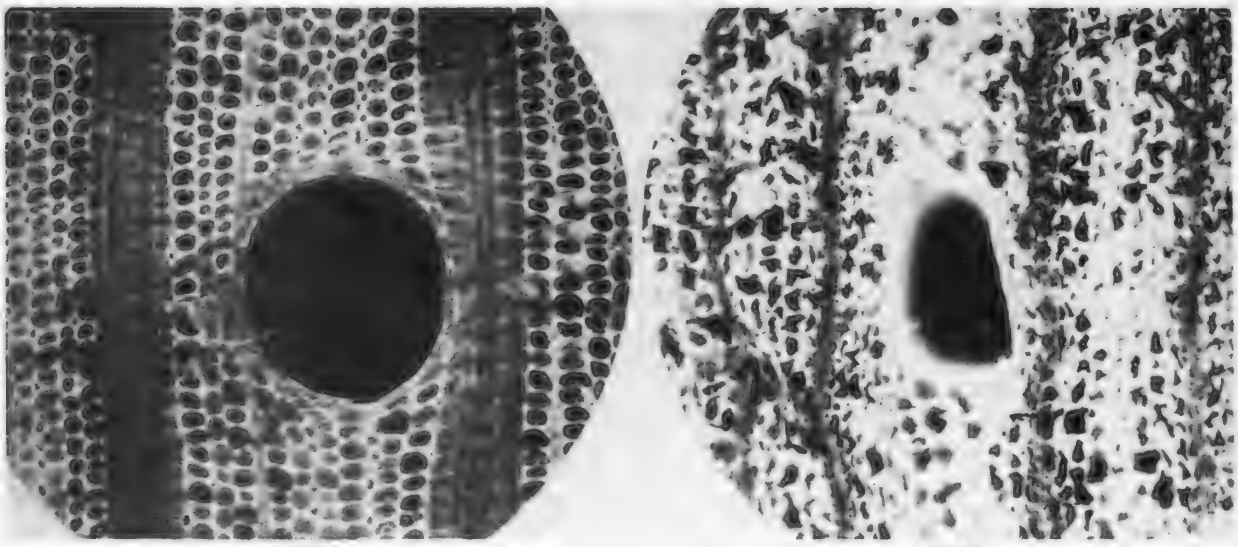

Fig. 4.—End-grain reflection fluorescence photomicrograph (X100) of balsa in original air-dry condition (before). End-grain reflection fluorescence photomicrograph (X100) of balsa soaked in liquid ammonia and subsequently air-dried, showing extensive collapse (after).

After two hours, the liquid ammonia was poured from the bag, and the bag and specimens were removed from the bottle. The specimens had just a detectable odor of ammonia and had swollen just a perceptible amount.

The experiment was repeated with liquid ammonia in the bag for 24 hours. A moderate odor of ammonia was given off from the specimens after dissembling. The tangential swelling was about a quarter of that obtained when the specimens were immersed in liquid ammonia. On air drying, only a small amount of collapse occurred. Over a long exposure period, the balsa could adsorb ammonia up to the fiber saturation point. This increased swelling should, however, not cause collapse on drying because the capillary structure will not fill as it does in direct liquid immersion. This experiment shows that wood storage tanks could be used if they had liners with permeability to liquid ammonia no greater than that of rubber dam.

Measurements were made of the weight loss of the wood specimens after soaking for 6 days in a large excess of liquid ammonia at about —36° C. Sitka spruce lost only 0.5 of its original ovendry weight; Douglas-fir, 3.8 per cent; redwood, 11.8 per cent; and balsa, 1.6 per cent. The values are about of the same order of magnitude as would be expected for hot-water extraction.

Conclusions

Liquid ammonia near its boiling point swells wood more rapidly than does water at room temperature. In the tangential direction the external equilibrium swelling for softwoods is 30 to 45 per cent greater in liquid ammonia than in water. In the radial direction, the swelling of Sitka spruce and redwood is about the same as in water, but for Douglas-fir it is greater. The external swelling of balsa is less in liquid ammonia than in water. However, a large internal swelling must occur, because the cell walls are plasticized to such a degree that a very large amount of collapse occurs on subsequent drying. The softwood species also collapsed to a prohibitive degree on drying after soaking in liquid ammonia. The collapse occurs in conformity to the Tiemann theory (21).

The large collapse would make unlined wooden tanks unsuitable for storage of liquid ammonia. When lined with light rubber dam, the penetration of liquid ammonia is sufficiently small so that swelling and subsequent collapse on drying are not serious.

Liquid ammonia dissolves extractives of wood to about the same extent as hot water.

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Extract Stimulation for Wood Rosin Production—Increasing the Extractive Content in Ponderosa Pine[1]

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Experiments are underway to determine effective ways of increasing resin production within young pine trees, with an objective of using this as a possible source of wood naval stores products. A promising method of extract stimulation is placing a deep incision across the face of the tree and adding 40 per cent sulfuric acid to the wound. Within six months, a relatively large area about the incision contains as much resin as is present in old-growth stumps.

WOOD ROSIN, TURPENTINE, AND PINE OIL are obtained commercially from old growth southern pine stump wood. These resinous stumps, mostly longleaf *(Pinus palustris)* and some slash pine *(Pinus elliotii)*, are harvested, chipped, and extracted with a solvent for the recovery of these wood naval stores products. This industry has been in production for about 45 years, the products of which augment the supply of gum rosin and turpentine obtained from oleoresin furnished by the living tree (14).[2] The resulting demand over the years for old-growth pine stumps has been making serious inroads into the supply of stumps suitable for extraction. This depletion problem is reflected in a recent survey made in Mississippi which revealed that the total remaining supply of suitable stump wood in that state was about 6½ million tons (1950), roughly enough for about 10 more years of operation under present production rates (16). Thus, if new sources of resinous southern pine wood are not forthcoming, the output of some wood naval stores plants will be seriously curtailed.

It has long been known that the regular turpentining procedure does not usually produce a sufficient volume of resinous wood, often referred to as pitch soaked wood, behind the turpentine faces to warrant its use as a source of wood naval stores (9). This has likewise proved to be the case when chemicals (6, 15) or fungal agents (3) are used for producing greater stimulation of oleoresin flow from turpentined trees.

The writer's interest in the production of resinous wood stems from an observation made about ten years ago after examining a resin streak in ponderosa pine *(Pinus ponderosa)* sapwood caused by an embedded bullet (1) (Fig. 1). This pitch streak, several inches above and below the bullet, contained about 22 per cent benzene soluble extract, while the surrounding, normal sapwood averaged but 2 per cent extract. Thus, this lodged bullet stimulated the production of extractives in the sapwood area to an amount approaching the quantity of resinous extract found in old-growth ponderosa pine stump heartwood (2).

Fig. 1.—Excessive extract production due to embedded bullet.

This observation that certain types of wounds in coniferous sapwoods, whether by bullet, increment boring, or some other type of injury, results in the formation of resinous deposits is well known. It appears, however, that few studies have been carried out to determine some of the more effective ways of increasing resin production within pine trees to yield highly resinous wood with the objective, among others, of using the wood produced as a possible source of wood naval stores.

The preliminary attempts at extract stimulation were carried out on young ponderosa pine trees. After several trials, it was found that one of the most effective ways of increasing the extract content within the tree was to make an incision well beyond the cambium and into the sapwood across the face of the tree. Periodically, sample borings were taken at different levels above and below the wounded area and quantitatively analyzed to determine rate and extent of excessive resin production. Within a period of six months after wounding, the six-inch levels above and below the wound showed evidence of slight increases in extractive content.

It was found, however, that the addition of sulfuric acid (40%) into the incision immediately after wounding, greatly enhanced the rate and extent of resin production within the tree. After a lapse of several years, these experiments were again taken up. This is a preliminary report on the extract stimulation of ponderosa pine, with some information on the chemical composition of the extract produced.

Method of Wounding Trees

The experiments were carried out at Black's Mountain Forest and Range Experiment Station, California. Four ponderosa pines were chosen at random. These were from 21 to 28 inches d. b. h., of Dunning Tree Class I, and growing at 4,500 feet elevation in a

[1] A contributed paper. Presented in part before the Wood Chemistry Symposium, XIII International Congress of Pure and Applied Chemistry, July 29–August 4, 1953, in Stockholm, Sweden.

[2] Numbers in parentheses refer to literature cited.

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mixed stand of Jeffrey pine *(Pinus jeffreyi)*.

The trees used were identified as ponderosa based on the morphological and anatomical features of the cones and foliage. In addition, the sulfuric acid solubility test of the volatile oil from each tree was determined to ascertain whether any of these trees might be natural hybrids of ponderosa and Jeffrey pine (17). Since at least 95 per cent of the steam volatile portions of the extracts were soluble in concentrated sulfuric acid, hybridity appears to be excluded.

Zobel showed that only about 7 per cent of the volatiles from Jeffrey pine oleoresin dissolved in sulfuric acid. This would be expected, since Jeffrey pine volatiles contain about 95 per cent of the saturated hydrocarbon, n-heptane (13). On the other hand, since the steam volatile from ponderosa pine contains no saturated hydrocarbons (13), it would be expected to be more or less completely soluble in concentrated sulfuric acid (17).

Increment boring were also obtained from each tree at wound level to determine depth of sapwood, rate of growth, age of tree, and quantity of extract present in the normal sapwood.

The wounds were placed in the trees by driving a thin, sharp, metal loggers' falling-wedge, at slightly downward angle, across the face of the tree, about 16 inches above ground level and about 4 inches deep beyond the cambium. The wedge was removed and the wounding continued until there was a continuous incision across ¼ to ⅓ the circumference of the tree. In two trees, i.e., 11 PP and 12 PP, 40 per cent sulfuric acid was introduced into the wound by means of a polyethylene wash bottle until the nearly closed incision was filled with the chemical stimulant. The wounds in trees 9 PP and 10 PP received no acid treatment. This procedure of wounding was carried out during the latter part of May.

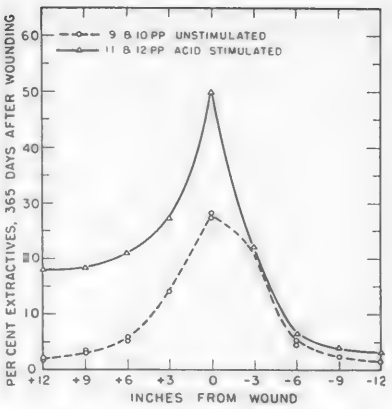

Fig. 2.—Distribution of extractives about wounded areas.

Sampling and Extraction

Five months after the wounds were placed in the trees, 4-inch deep, ¾-inch auger and bit borings were taken from each tree at 1, 3, 6, 9, and 12-inch levels, above and below the wound. After each boring, a cork was inserted in the hole to minimize the possibility of entry of pathogens and insects. A portion of each sample boring as received was then extracted, in duplicate, with acetone in Soxhlet extractors for 6 hours and the quantity of extract determined, corrected for moisture content, as determined by the benzene-distillation method. This procedure of sampling and extraction was again repeated one year after the wounds were placed in the trees. The extractive content at the various levels and time intervals is reported in Table 1.

(Note: The average of extractive content at 1 inch above and 1 inch below the wound is reported here as amount of extract present at wound level.)

Amount and Distribution of Stimulated Extract

As indicated in Table 1, the greatest quantity of extract is found at the incision and gradually diminishes beyond the wounded area. While the pattern of distribution is somewhat irregular, it appears that a slight increase in extract content occurred up to the 6- to 9-inch levels beyond the incision during the 150 day interval after wounding in the untreated trees, i.e., 9 PP and 10 PP. However, during this same period, even at 12 inches above the wound, the acid stimulated treatment produced about seven times more extract than the corresponding level in the untreated wound. It will also be noted that more extract was produced above the incision than below, in the acid stimulated wounds. (Fig. 2)

The average extract content over the 24-inch area had increased to 8.7–9.4% in the untreated wounded trees. On the other hand, the acid stimulated trees, 11 PP and 12 PP, during the same periods over a comparable area, averaged 17.8–18.9% extract or approximately twice as much as the untreated wounds. Thus, it becomes apparent that the presence of acid in

Table 1.—PER CENT EXTRACTIVES IN WOUNDED TREES

Tree Number	9 PP	10 PP	Av. 9–10 PP	11 PP	12 PP	Av. 11–12 PP
D.B.H., in.	24	21	----	28	25	----
Stimulant	No	No	----	Yes	Yes	----
Days after wound	150	150	150	150	150	150
Inches from Wound	Per Cent Extractives (dry basis)					
+12″	1.7	2.3	2.0	15.7	14.3	15.0
+ 9″	2.5	3.8	3.1	21.8	16.7	19.2
+ 6″	6.4	4.0	5.2	26.3	19.5	22.9
+ 3″	14.8	13.9	14.3	28.6	25.7	27.1
0	30.0	25.0	27.5	46.6	30.6	38.6
- 3″	27.6	6.3	16.9	10.9	23.0	16.9
- 6″	7.1	3.3	5.2	4.3	15.1	9.7
- 9″	3.2	2.1	2.6	6.5	7.0	6.7
-12″	1.9	1.0	1.5	4.9	4.2	4.5
Average	10.6	6.8	8.7	18.4	17.3	17.8
Days after wound	365	365	365	365	365	365
	Per Cent Extractives (dry basis)					
+12″	1.9	1.9	1.9	21.9	14.6	18.2
+ 9″	3.1	3.9	3.5	23.1	14.5	18.8
+ 6″	5.1	6.2	5.6	26.1	15.7	20.9
+ 3″	6.9	19.3	13.1	32.7	21.6	27.1
0	29.3	27.3	28.3	54.8	44.8	49.8
- 3″	38.8	10.5	24.1	18.2	25.5	21.8
- 6″	4.7	4.5	4.6	2.5	10.3	6.4
- 9″	2.5	2.6	2.5	2.0	6.1	4.0
-12″	2.1	1.2	1.7	3.1	3.3	3.2
Average	10.4	8.6	9.4	20.5	17.4	18.9

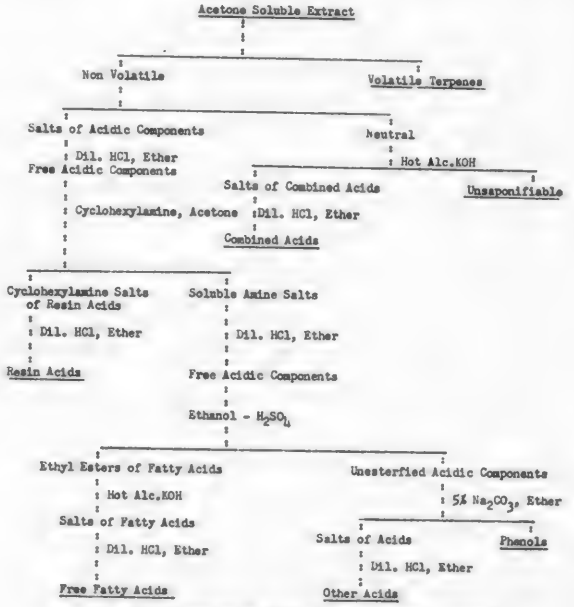

Fig. 3.—Separation of extractive components.

the wound stimulates the parenchyma cells to produce additional quantities of extract (7).

In cutting a cross section through the trunk, it was observed that the deposition of excessive resin production had about the same dimensions as the area of the incision, above and below the wound. Extract stimulation did not appear to take place laterally beyond the dimensions of the incised area. Since approximately one-fourth of the cross-sectional area of the trunk was covered by the incision, a corresponding amount of the entire trunk about the wound contained resinous wood approaching 24 inches in length in the acid stimulated wounded trees. Best commercial practice would demand a greater cross-sectional area of resinous wood in order to increase the overall resin yield from the entire bolt. Experiments are now underway to determine how extensive chemical extract stimulation wounding can be made in the tree circumference and still maintain tree survival.

In determining the amount of extract at the various levels, it was observed that the moisture content of the samples decreased as the amount of extract increased. It is too early to conclude whether the extract replaced the water in the cells as it was being produced, or whether extract was being produced due to the gradual dehydration of the living cell.

Extract Composition

The acetone soluble extracts obtained from the various sample borings (150 days after wounding) were separated into component fractions as outlined in Fig. 3 and the results are summarized in Table 2.

As can be observed from the percentage component fraction composition, the predominating components produced during extract stimulation are resin acids, volatile terpenes, and esters (combined acids). The only constituent which does not appear to enter into extract stimulation is the free fatty acid component. Thus, as is indicated, when the normal physiological processes of extract production in the tree is interrupted by wounding, the defensive mechanism initiated by this abnormal condition not only induces the tree to lay down a heavy deposition of extract, but likewise produces a remarkable change in per cent component fractions.

Stimulated Extract and Normal Wood Extract

When sapwood in conifers is transformed into heartwood during tree growth, it is well known that the extractive content of the latter usually increases, accompanied by a change in component fraction composition. Little is known about the chemistry and biosynthesis that takes place during this transition stage.

In order to compare the nature of the extract found in the extract stimulated area with that present in the heartwood, as well as in normal sapwood, it was of interest to examine these portions of the tree. For this purpose, trees 10 PP and 11 PP were felled and the sapwood and heartwood from the butt portion of the log adjacent to the wounded area were segregated and prepared for analysis.

The per cent of component fractions found in the sapwood and heartwood acetone soluble extracts, together with that found in the extract from the extract stimulated areas is reported in Table 3. A better appraisal can be arrived at if the per cent component fraction data are expressed as grams of each component fraction produced from 100 grams of extract—and moisture-free wood. These data are graphically illustrated in Fig. 4.

These results clearly indicate that the predominating extractive component change in the transition of sapwood into heartwood is the increase

Table 2.—PER CENT COMPONENT FRACTIONS OF EXTRACTS FROM WOUNDED AREA (150 DAYS AFTER WOUNDING)

Trees 9 PP and 10 PP

Extract from	Volatile	Res. Acids	Fatty Acids	Other Acids	Phenols	Comb. Acids	Unsap.	Per cent Extract
+3"	9.3	45.3	6.2	8.2	4.1	22.7	4.1	14.3
+1"	13.0	48.7	7.8	10.8	2.6	12.1	5.0	22.4
−1"	14.4	56.8	3.1	8.2	1.0	10.8	5.7	34.8
−3"	8.0	54.2	7.2	11.4	1.2	15.3	2.4	16.9
Average	11.1	51.1	6.1	9.6	2.2	15.2	4.3	22.1
−6, −9, −12"								
+6, +9, +12"	1.0	17.1	40.0	8.3	1.5	29.0	3.0	3.1

Trees 11 PP and 12 PP

Extract from	Volatile	Res. Acids	Fatty Acids	Other Acids	Phenols	Comb. Acids	Unsap.	Per cent Extract
+12"	16.4	45.5	2.8	7.0	2.3	20.1	5.6	15.0
+9"	13.8	47.4	1.5	6.2	2.6	23.0	5.2	19.2
+6"	17.4	48.1	2.2	5.0	0.9	23.0	3.1	22.9
+3"	16.5	48.8	2.2	7.6	0.9	20.7	3.1	27.1
+1"	20.4	55.5	5.6	5.0	1.7	8.0	3.8	39.9
−1"	20.3	53.0	5.0	6.0	2.0	10.0	3.5	37.2
−3"	14.0	45.5	1.7	5.6	2.8	28.2	2.2	16.9
Average	16.9	49.1	3.0	6.0	1.9	19.0	3.8	25.4
−6, −9, −12"	7.7	24.0	24.7	9.3	2.3	28.6	3.1	7.0

Table 3.—PER CENT COMPONENT FRACTIONS IN EXTRACTIVES

Tree #10 PP

Extract from	Volatile	Res. Acids	Fatty Acids	Other Acids	Phenols	Comb. Acids	Unsap.	Per cent Extract
Heartwood	13.4	49.2	6.5	3.8	10.0	9.4	7.6	15.0
Stimulated Wood Area	11.1	51.1	6.1	8.9	2.2	16.0	4.3	22.1
Sapwood	1.0	16.1	32.8	8.5	1.8	35.7	4.2	1.5

Tree #11 PP

Heartwood	13.1	53.5	5.2	4.0	9.8	9.6	4.5	26.0
Stimulated Wood Area	16.9	49.1	3.0	6.0	1.9	19.0	3.8	25.4
Sapwood	Trace	6.0	42.0	8.5	1.3	39.8	2.3	3.5

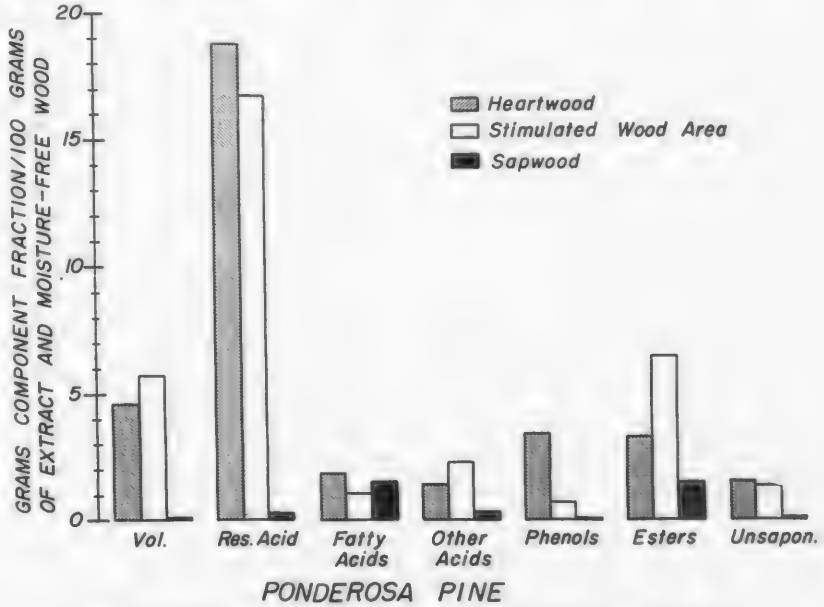

Fig. 4.—Comparative component composition of extracts from stimulated area, heartwood, and sapwood.

in volatile terpenes, resin acids, and phenolics. The only component which has not changed quantitatively appears to be the free fatty acid constituents. Thus, it would appear that in the transition of sapwood to heartwood, a biosynthesis is induced to produce all component fractions, except free fatty acids. Interestingly enough, it would appear that the percentage component fractions of the stimulated extract approaches that found in the heartwood (see Fig. 4). Consequently, the question may be posed as to whether the stimulated extract area has been converted to heartwood.

One of the well-known sensitive color reactions used to distinguish pine heartwood from sapwood is the direct application of a solution of bis-diazotized benzidine to wood (8). When this solution is applied to pine wood, the heartwood becomes red, while the sapwood remains yellow. Erdtman found that this red color in the heartwood of Scots pine *(Pinus silvestris)* was due largely to the presence of the phenol, pinosylvin (4). In later studies, Erdtman and coworkers found that the pinosylvin type of heartwood component is characteristic for the whole genus *Pinus* and that certain flavonones and flavones were also characteristic of pine heartwoods (5).

While it was thought that these compounds were essentially true heartwood constituents, paper partition chromatography studies by Lindstedt and Misorny revealed that traces of these phenolic compounds also appear to be present in the sapwood of a number of pine species examined (10). This observation, among others, suggested to these investigators that these compounds are formed in the cambium and are transported radially through the sapwood via the medullary rays and finally accumulate in the heartwood. These phenolic compounds are of functional interest since they are strong fungicides and are believed to be largely responsible for the decay resistance of pine heartwood.

In investigating the phenolic constituents present in ponderosa pine heartwood, Lindstedt reported the presence of pinosylvin, pinosylvin monomethyl ether, pinocembrin, and pinobanskin (10, 16). Each of these compounds gives a characteristic red color with bis-diazotized benzidine solution and this reagent was used as the chromogenic agent to spot these phenolic constituents in paper chromatography studies (10).

In the present investigation, the phenolic fraction from the heartwood gave an intense brick red color when treated with a solution of bis-diazotized benzidine. Upon submitting this fraction to the chromatography method developed by Lindstedt (12), spots were found at Rf values 0.06, 0.14, 0.50, and 0.74, which indicate the presence of pinosylvin, pinobanksin, pinocembrin, and pinosylvin monomethyl ether, respectively.

When the corresponding phenolic fraction from sapwood and stimulated extract were so tested, only very weak spots, at best, could be detected for each of the above four compounds. Thus, while the stimulated extract may contain traces of the heartwood phenolics, the amount did not apparently exceed the quantity found in normal sapwood. This was further indicated for when the benzidine solution was applied directly to the extract stimulated wood area, the color imparted to the wood surface was about the same as that shown in the sapwood.

While the major difference between the heartwood and stimulated extract may reside in the quantity and type of phenolic substances present in the heartwood, much more data are necessary before any conclusions can be reached relative to the nature of the metabolism involved in laying down a heavy deposition of extractives in sapwood brought about by wounding. This likewise is true for ascertaining the nature of the chemical changes involved in the transformation of sapwood to heartwood.

Extract stimulation may prove to be a useful tool in expediting the solution to this complex problem. This should include, of course, a detailed study as to the chemical identity of the various constituents present in the extractives of sapwood, heartwood, and extract stimulated wood. These investigations are now underway.

Discussion of Results

The method of extract stimulation outlined here demonstrates that considerable quantities of extract can be produced, *in vivo,* in ponderosa pine sapwood in a relatively short time. The extract, so produced, approaches the amount of extract found in the butt heartwood of old growth pine trees. Further, it has been shown that stimulated extract approaches the chemical component fraction composition of the extract found in heartwood.

Extract stimulation may have potential commercial application. The southern pine region is being depleted of old-growth pine stump wood which is used in the production of wood naval stores. Perhaps young second growth pines, which contain very little extract, can be made to produce heavy concentrations of resin in the stump wood area prior to falling, which may serve as a suitable commercial source of resinous wood. Preliminary studies on extract stimulation of southern pines, as well as other conifers, are underway.

Acknowledgment

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Effect of Cutting Angles in Woodworking with Carbide and Steel Cutters[1]

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Study of cutting angles shows the importance of knife position in woodworking. The finish obtained in machining edges of veneered panels with carbide knives is illustrated. The surfacing qualities given by three different cutting angles are shown.

Introduction

MOST OF THE THINGS that we see and own have required machining in some way or other and this transformation is done more or less economically depending upon the tools used. All materials are different and so are their machinabilities and the tooling that transforms them. Although different types of tools may be used to give similar results, there is an ideal tool which will do each job best and most economically whether the material is steel, glass, diamond, plastic, or wood.

Tradition and habit are strongly entrenched in the wood-working industry and there is an obligation to study, so as to supersede by better tooling and methods, those outmoded techniques that the higher cost of raw material and labor no longer justifies.

In the mechanical woodworking industry, operations in which cutting tools are employed occupy an important position. For this reason it seems strange that research so far has directed but little attention to the cutting operation iself. This may be due partly to the relative ease with which wood can be machined as compared to the cutting of metals and partly to the difficulties encountered by research techniques because of the non-homogeneous structure of wood. On the other hand, the lack of precise research results has become increasingly evident to manufacturers. Therefore, it is believed that although these tests and results are incomplete, they should be published now.

The scope of this report should be considered merely as a contribution in exploring the important factor of the cutting angles, based on an industrial test: the shaping of 72 solid-core veneer-faced panels at three different cutting angles namely 10°, 18°, and 33°. The classification of the results is visual and based on the quality of the finish obtained from typical samples.

Explanation of Terms

As usually understood, the term "cutting angle" refers to the angle between a diametral line to the end of the cutter edge and the cutting face of the knife. The term "sharpness angle" refers to the included angle between front and back faces of the knife, while the term "clearance angle" refers to the space preventing the rubbing of the knife heel against the work. The larger the cutting and clearance angles, the smaller the sharpness angle will be.

It has been established that the orientation of the wood structure and its density requires different cutting techniques and a distinction should be made accordingly between the three main cutting directions: across the grain, along the grain (planing), and with the grain (unrolling veneer). This study refers only to the cross grain and along grain cutting operations and combinations of both.

The cutting of green wood is quite different from that of cutting dry wood. Wet wood has a natural lubricant. Hence clearances are less important in wet wood than in dry, and the cut surface can be rougher, since subsequent machining after drying will produce the smooth surfaces required. Therefore, cutting tools must be appropriate for green or dry wood.

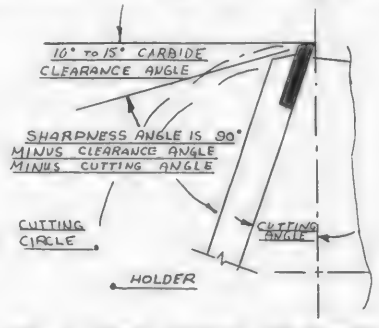

Fig. 1.—Cutting, clearance, and sharpness angles for carbide cutters. Note: Carbide sharpness angle grade: 883 from 50° to 60°; 44A from 45° to 50°; 55A from 40° to 45°. For high speed steel cutters, clearance angles of 15° to 25° are recommended.

Testing Equipment

This industrial test was made as precisely as possible with the following equipment: an Onsrud Shaper, Model W 125, with variable feed rotating table and a two-knife cutter head revolving at 7200 R.P.M. A power indicator was used to note the power consumption required for the different cutting angles.

Carbide grade 883 straight knives (no pattern factor) 2 in. wide with a 4 in. diam. cutting circle were used. The knives were set with accuracy but no jointing was done. The three following sets of cutters were used:

	Cutting Angle	Sharpness Angle	Clearance Angle
#1	10°	65°	15°
#2	18°	57°	15°
#3	33°	42°	15°

Knives were freshly ground with a 220 grit straight type 6-in. diam. diamond wheel. The shaper head revolved in a climbing direction into the wood, thus producing a superior finish compared to the conventional shaping method. However, the latter would have a greater effect upon the importance of the cutting angle, and the conclusive results of the test would have been more evident under such conditions.

Test Material

The types of wood tested were: basswood, plain-grained yellow birch, curly-grained yellow birch, and sugar maple. Panels consisting of a 11/16-in. core, faced with 1/28-in. birch veneer of characteristic grain, were selected to represent a general production run. The moisture content was between 7 and 9 per cent. The depth of the cut was not constant, and varied from 1/8 in. to 1/4 in. from a rough surface. The feed was at 16 feet per minute. Because the two knives were not

[1] Presented at meeting of Northeast Section, FPRS, April 28–29, 1955, in Glens Falls, N. Y.

The Author: Robert Chateauneuf has been employed by Singer Manufacturing Co. for eight years, has specialized in carbide tooling for past five years. He was formerly employed in the fiber and plastics manufacturing field. A FPRS member, he also belongs to Professional Technicians Assoc. Singer Engineering Society.

Fig. 2.—The 33° cutting angle finish is definitely superior in the cross grain direction. The finished quality of the 18° angle is between the 33° and 10° angle and is not recommended for low density wood (e.g. basswood).

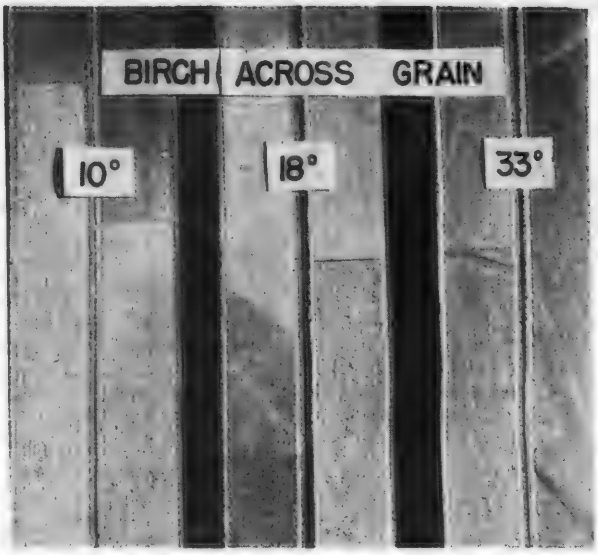

Fig. 3.—Good results may be obtained with the 18° angle when cutting thin layers of hardwood (e.g. veneer) or in variable direction cutting. The 10° angle has a tendency to compress the fibers before cutting them, which is more noticeable in low density wood. It is not recommended for cutting across the grain.

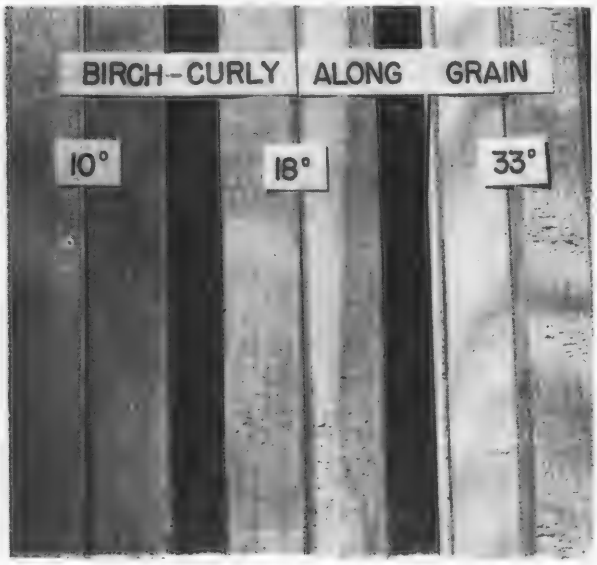

Fig. 4.—The 10° cutting angle is recommended when cutting fussy grains (e.g. curly bird's-eye maple and knotty woods). Angles greater than 20° will not give a serviceable finish.

Fig. 5.—The 18° angle is advantageous for average shaping of ordinary hardwood having some cross grain portions. The 33° angle should not be considered when cutting along the grain, especially in dry wood for furniture purposes.

jointed we can assume that the finish was produced by one knife only.

The following observations were noted and are summarized to serve as conclusions. Some of the statements may not be related directly to the subject but are of such importance that they should be included.

Observations and Recommendations

Alteration of the cutting angle is sometimes an effective method of obtaining better surface finish and economy in subsequent operations, such as sanding and polishing. Reduction of the cutting angle causes a greater force to be exerted in the direction of feeding but a decreased force to be exerted at right angles to the face of the board being shaped.

Neither knife sharpness or dullness can be precisely defined. A high degree of sharpness is not necessary because it wears away very rapidly. A carbide tool need not duplicate the high sharpness angles necessary for steel cutters, because it remains sharp longer and is not dependent upon a small sharpness angle to provide a narrow cutting edge after the cutter has reached a certain dull stage. Carbide sharpness angles should not be as small as tool steels since the granular nature of material will not support the stresses associated with small sharpness angles. Carbide itself will not produce better work than ordinary steel tools. It is the wearing qualities and prevailing conditions that favor carbide tools so greatly.

Low density wood requires a larger cutting angle (25°–35°) and a smaller sharpness angle; this is more evident in the cross grain cutting operation, since the structure of the wood has no support. A rounded cutting edge finds it extremely difficult to shear the grain, hence the fibers are often torn deeply from below the cutting edge.

Knife clearance angle should be kept to a minimum to permit a maximum sharpness angle. Ten to 15° clearance is recommended for carbide and 15°–25° for steel knives. The smaller the cutting circle the more clearance is required.

In conventional surfacing along the grain, chip deflection is facilitated by large cutting angles. With large cutting angles the chips will bend only slightly and any giving that occurs is less likely to continue below the cut surface. A chipbreaker within 1/16 in. to 3/32 in. from the cutting path will also help to obviate this effect. As a general rule it can be stated that, for a given chip thickness, the quality of the cut surface is best when a suitable chipbreaker can be used.

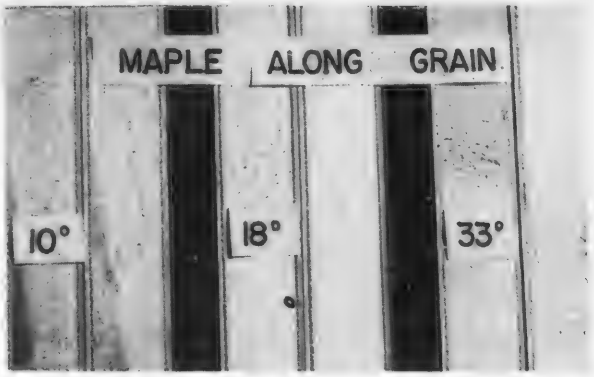

Fig. 6.—The 10° angle used on bird's-eye maple produced a fine finish. The 18° angle used on ordinary grain gave excellent results. The 33° angle, however, produced some veneer chipping and lifting of the wood fibers.

Fig. 7.—The cutting angle effect is not as noticeable when cutting lower density wood along the grain. The 10° and 18° angles produce a good appearance but some fine fibers like hair are raised. This effect is not apparent when using a larger angle such as 33°. A 25° to 33° angle is therefore recommended for cutting lower density wood across and along the grain.

Table 1.—RECOMMENDED CUTTING CONDITIONS

Kind of Wood	Green			Air Dried			Kiln Dried		
	Across Grain	Along Grain	Knife Cuts	Across Grain	Along Grain	Knife Cuts	Across Grain	Along Grain	Knife Cuts
	Cutting Angles		Per inch	Cutting Angles		Per inch	Cutting Angles		Per inch
Ash	40–35	25–20	10–12	35–30	20–15	12–16	30–25	15–10	14–18
Basswood	40–35	30–25	8–10	35–30	25	10–14	30–25	25–20	12–16
Birch (Plain)	40–35	25–20	10–12	35–30	20–15	12–16	30–25	15–10	14–18
Birch (Curly)	40–35	20–15	10–14	35–30	15–10	14–18	30–25	10–5	16–20
Mahogany (Hard)	40–35	20	10–12	35–30	15–12	12–16	30–25	15–10	14–18
Maple (Plain)	40–35	25–20	10–14	35–30	15–10	12–18	30–25	12–7	16–20
Maple (Bird's Eye)	40–35	20–15	12–16	35–30	12–7	14–18	30–25	10–5	16–20
Oak	40–35	25–20	10–12	35–30	12–15	12–16	30–25	10–15	12–18
Walnut	40–35	20	10–12	35–30	20–15	12–16	30–25	18–12	14–18

Note: The above figures of knife cuts per inch should give from good to excellent finish.

Cutters will not give an outstanding performance when the spindle speeds are too slow in relation to the work feed being used. Greater speeds are desirable for carbide, thus production capacity increases since the feed factor is then increased proportionally. Sufficient wood should be made available for a definite cut. It has been found that the best output from a cutter can be obtained by minimizing the initial rubbing and arranging for the maximum amount of wood being removed at each cut. For this reason and to reduce the feeding power, more than 20–25 knife cuts per inch are not recommended.

To prevent raising the grain on wet or green stock, increase the cutting angle and reduce the knife cuts per inch. To prevent tearing out on dry stock, decrease the cutting angle or increase the knife cuts per inch or use the climb cutting method. Recommended cutting angles and number of knife cuts per inch are given in Table 1.

Cellulose Fiber Cores for Molding[1]

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Describes a method for producing molded products of high strength and light weight, using common box-making techniques. Problems in use of the soft core selected included: blistering, delamination, resin impregnation of core, resin distribution, and mold release. Some items have been satisfactorily manufactured, but additional research is needed to solve some problems.

THE USE OF SANDWICH CONSTRUCTION in flat panels and in objects fabricated from flat panels is by no means new. The relative physical properties obtained by combining two materials to improve the physical properties of both is well recognized. Probably one of the most outstanding examples in most common use is the lally column.

In the core field, the honeycomb and balsa wood core has been outstanding in recent engineering work. Some core molding has been done with hand layup and vacuum bag processes. The outstanding example of this work is the radome construction. In most instances honeycomb or balsa wood cores have been used.

The development discussed in this paper is of an entirely different nature. The theory and the aim is to manufacture high strength articles using common box-making techniques, presumably of the paper setup box type whereby a low cost core or preform can be obtained with existing high speed machinery. The low cost core is then covered with a thin layer of high strength fibers, usually glass, the resin applied and the whole preform placed in the mold.

There were many problems connected with this theoretical proposal, some of which are in the state of partial solution, and each will be discussed individually.

[1] Presented at meeting of Northeast Section, FPRS, Nov. 4–5, 1954, in New York City.

The Author: W. Burdette Wilkins is a consulting engineer, specializing in production machine design and composite plastic constructions. A charter member of FPRS, he was formerly Northeast Regonal Member of the Executive Board.

Design

It was found that selection of the core depended a great deal upon the radii that were able to be obtained in the corners. If a hard stiff paper was used, radii must be kept to a minimum. If a soft spongy core was used, a greater latitude was obtainable in radii and compound curve. With a stiff heavy chip board, gentle compound curves were not too difficult. In the corners of a box, the radii must be kept to not over ⅜-inch and in a good many instances, added glass must be used in corners.

With the softer boards, ¾-inch and probably 1-inch radii could be accomplished in the corners without too much trouble. By the use of soft core, strengthening ribs are possible and reasonably feasible in the design of a structure wherein molding with just the glass alone ribs are a difficult problem. The crushability of the core is the medium that provides side pressure on a rib.

Thick and thin side sections of the side wall of a box are also feasible and are accomplished by die cutting sections out of the core. These changes in wall thickness allow for recessing hardware, handles, etc., which has always been a serious problem in normal molding. Large flat areas in a high strength structure should be avoided as far as possible unless some method was used to prevent delamination. One of the serious drawbacks in designing molding of this description is that the minimum draft allowable is about 4 degrees and it is preferable to have even more.

Blistering is a serious problem. The composition of the cores must be carefully selected and in some cases specially made. One big offender is the presence of starch, for when the mold temperatures are carried as high as 250 or 300 degrees for rapid cure, it will create blistering which will delaminate flat areas. Careful moisture control is of great assistance in this respect. Large flat areas must have careful consideration and in many instances should be broken up by a complete glass wall.

Delamination

Many of these cores, especially the softer ones, are built up in layers and have little strength parallel to the layers. Depending upon the end use requirements of the object to be molded and the weight factors desired, different methods have been used to prevent delamination. The most successful is threading or needling the core. This means driving fibers completely through the core and letting an inch or two lie on either face. The fiber that is thus exposed on the faces is bonded securely to the tension or compression face, as the case may be, and prevents delamination.

In several instances, the shape of the object being molded does its own tying so that delamination, although it may occur in the short flat areas, does not seriously affect the strength of the structure. In some instances, merely holes punched in the soft core or hard cardboard will give sufficient tie between the compression and tension face to avoid trouble. Complete impregnation of the core is, of course, possible but adds considerably to the weight and the cost.

Weight Factor

One of the principal reasons for this development was to obtain a rigid object at a low cost but still maintain a light weight. In these instances, the soft core was preferable but the problem of preventing the resin from impregnating the core was a serious one.

A number of liquid sealants have been tested with varying results. Some of them have been reasonably successful; one of the cheapest and fairly successful ones is common wheat paste. However, the best results have been obtained by using a barrier sheet of thin paper wherever the shape of the structure made this feasible. In some cases both paper and liquid sealants were used—a protective paper barrier sheet on the flat areas, and a liquid application on the edges and compound curves.

Fastening Hardware

Fastening hardware is no problem whatsoever where cardboard is used because the board is of sufficient density to hold rivets, etc. In the case of the soft core, it is quite feasible to mold in a dense material in these areas to obtain good backing for rivets. Inserts of various kinds can also be molded in successfully because the core, which constitutes the majority of the preform, is stiff enough and accurate enough for the inserts to be held in place by the core.

Another advantage in molding boxes that require an air tight seal is that the wall thickness is heavy enough to allow molding of a recess, usually a half round, directly into the top edge of the box and also a corresponding groove inside of the lip of the cover so that no metal valance or attachment of foreign material, other than the gasket, is necessary to complete an air tight seal. It is preferable to have a ⅜-inch wall at this point in order to accomplish this successfully, although one box has been done with a 5/16-inch wall.

Distribution of Resin

In normal molding procedures using a glass fiber, it is common practice for the preform to be placed on the mold dry, the resin dumped on one or two places, the mold closed, and you get a complete fill out and a perfect piece.

In molding with a soft core, resin distribution is a serious problem. The core is so soft that the resin will not disperse to the various parts of the mold but will merely sink into the soft core leaving dry spots where the resin was not applied. Complete spraying or dipping of the prepared preform has been found necessary to keep the resin content down and to insure even distribution.

In some cases roller application might be applied, especially on structures where the surfaces were reasonably flat or where the preform could be handled flat and shaped after application of the resin. Too much handling cannot be done after application of resin due to the fact that the whole mass is gummy and sticky.

The actual molding was at first accepted as being a normal procedure. Considerable difficulty has arisen, however, on mold release due to two things. Some of the gases from the core given off under heat in the molds are contaminating the resins and making them sticky. The second is the small amount of shrinkage of the part, which does not allow easy removal. Knock out pins have been used with partial success. There is considerable work to be done on the best removal of pieces from the mold.

Examples of Molding

The following items have been manufactured by this method: 2,500 pound pallet for Quartermaster Corps, U. S. Army; pack board for Quartermaster Corps, U. S. Army; battery case, Signal Corps, U. S. Army; field telephone unit, Signal Corps, U. S. Army; and fishing tackle boxes.

Results

The results obtained so far have been gratifying. The first and probably the most important is high rigidity. The second is that the preform is of a reasonable rigid nature and can be handled. The preform will hold inserts in accurate position. The double skin provides a double moisture barrier. It is possible to mold thick and thin areas. It is possible to produce items that would be economically consistent with any other method.

However, this type of molding is still in its infancy and considerable more work must be done before it can be called a "Known Art."

An Analysis of Shook Yields from Box Lumber[1]

JOHN A. HARTSOCK

Assistant Chemical Engineer, Stanford Research Institute, Stanford, California

An analysis was made to determine the effect of size, grade, and kerf loss on shook yields from ponderosa pine lumber. A typical sample of rough box lumber was ripped to various common widths, marked for flaws, and photographed. The photos were analyzed to determine the yields of various representative sizes and grades of shook.

POSSIBILITY OF CREATING new kinds of shipping containers was the subject of a recent study by Stanford Research Institute for the Wooden Box Institute. Part of this work entailed the design of more economical types of wooden boxes. It was important that the shook incorporated in these designs should make the fullest possible use of the rough lumber from which it was sawn. In order to insure this efficiency, it was necessary to obtain some idea of the relative number of long and short lengths, and high and low grades, of shook which could be expected from an average sample of rough lumber.

Inquiries revealed that varied opinions existed among men in the lumber industry. Some mills had made private studies of the subject, but no published or quantitative data could be found. This meant that a method had to be devised for estimating the yields of different lengths and grades which would serve as a basis for analysis for any given sample.

The operators of a large shook mill helped with this analysis. They assembled the sample lumber, and their methods were used as standards. A description of this mill's operation, which is believed representative of most large mills, may make the analysis easier to follow.

Description of Shook Mill

In this mill, Nos. 3, 4, and 5 Common lumber are purchased for sawing into shook. The grades are not segregated for processing. The boards are about 1½ inches thick, 12 inches wide, and from 9 to 16 feet long.

This rough lumber is fed to the planer, where it is surfaced, and ripped to the desired width. It is then sent to the cut-off saws, where it is cut into pieces the length of the finished shook. The cut-off saws are fitted with several fixed stops so that the operator may quickly cut to any of several pre-determined lengths, depending on the type of shook desired.

Occasionally a piece comes from the cut-offs which is mostly sound, but has a defect on one side. The defect in such a piece may be removed with a band-rip saw, thus salvaging the usable wood. The 6/4 from the cut-off and band-rip saws is fed to the resaws, where it is sawn to the shook thickness. Generally, up to six resaws may be placed in line. Thus, many cuts may be made in a single pass.

If the resawn material is wider than desired, it may be ripped to narrower widths by profile saws, which are mounted at the end of the resaw line, or by a cleat machine. Cleat machines are often used on material that comes directly from the cut-off saws, but in this analysis they are considered only for use in ripping resawn stock.

These are the only operations considered here. The effect of using other specialized equipment, such as corner-post machines and Goff-end machines, has not been considered.

Factors Affecting Analysis

This analysis was primarily intended to supply information on the relative availability of different grades and lengths of shook. These yields are determined by two factors. First is the raw material—the kind of lumber from which the shook is cut. The second factor is the manner in which this lumber is sawn.

An analysis was wanted that would represent actual commercial operation as closely as possible; however, there were several problems:

A. Variations in Rough Lumber: Lumber is a natural, not a manufactured material, so no two boards are identical. No single sample of rough lumber could be selected to exactly represent all the box lumber sawn in the western states. Nor, on the other hand, could an analysis be made of all the wood that is handled in the west.

B. The Manner in Which the Shook is Sawn: 1. *Board Width.* Various board widths are used in cutting shook. Board width, as will be shown, has an effect on shook yields.

2. *Types of Shook Commonly Sawn.* Different kinds of shook are classed by their end use and each of these uses has its own size and grade specifications.[2] As an example, sides for standard type northwest apple boxes are ⅜ in. x 10½ in. x 19½ in. and may contain:

(a) One red knot 3 in. in diameter, or
(b) One red knot 2 in. in diameter and two black ring knots 1 in. in diameter, or
(c) One red edge knot not to exceed 3 in. across the face, or
(d) Three black rings knot 1 in. in diameter and two ¾ in. in diameter

The grading rules list about 50 different types of boxes and crates, each with its own size and grade specifications for ends, sides, and bottoms. Admittedly, some of these different types of shook may be similar; however, it would be an almost impossible task to analyze a sample of rough lumber for its yield of the large number of possible combinations of even part of these sizes and grades.

3. *Cutting Procedure.* The types of shook most desired by a mill vary from time to time. Any board may be cut up in several different ways, depending on the judgment of the cut-off saw operator and on the kind of shook wanted at that time. Thus identical boards, if they existed, might well be cut differently by the same operator if handled on different days.

4. *Kerf Losses.* It was also decided to consider the effect of kerf losses on different widths and thicknesses of shook. In general mill practice, shook footages are taken from the Tariff Tables. These figures actually include

[1] Presented at a meeting of the Northern California Section, FPRS, May 13, 1955, in San Francisco, Calif.

[2] National Wooden Box Tariff No. 1 and the Standard Grading Rules, 4th reprint, National Wooden Box Assoc., Pacific Div., San Francisco, Calif.

The Author: John A. Hartsock attended San Jose State College and U. of California, where he received B.S. in chemical engineering in 1950. He has been employed by Stanford Research Institute since graduation.

the kerf in the shook footage. Since these losses can be an important factor in the yield of thin or narrow shook, they had to be included in the analysis.

Approach to Factors Affecting Analysis

The problem, within time and cost limits, was devising an analysis that would give a reasonably reliable picture of the effect of different factors on shook yields. The procedure was as follows:

1. Rough Lumber Sample: The sample of ponderosa pine box lumber was assembled by the representative mill and, in the opinion of the mill superintendent, this was an average sample of the rough lumber they used.

2. Board Width: The sample was ripped into various, commonly used board widths. The shook yields in the boards of each width were then determined as described later.

3. Kinds of Shook: Time did not permit analyzing the sample for all the wide variety of sizes and grades of shook commonly produced. It was therefore decided to select a few representative lengths and grades, and determine their yields.

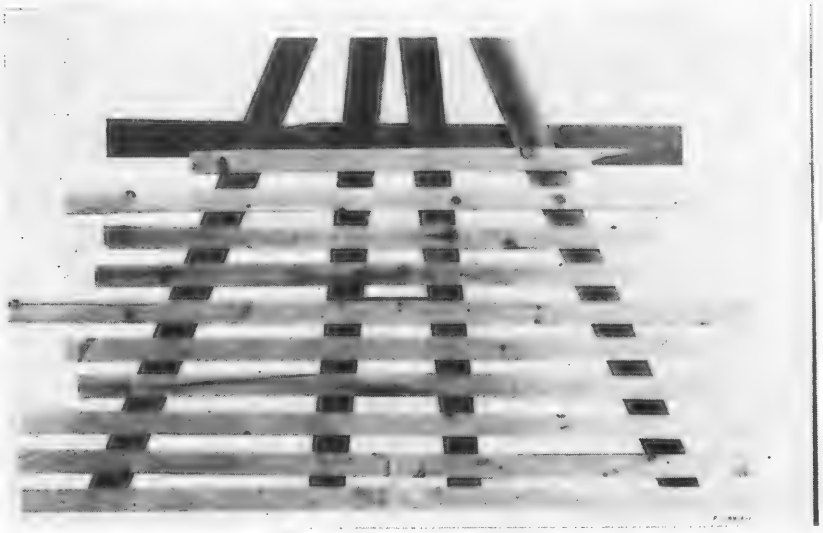

Fig. 1.—Rough lumber photo.

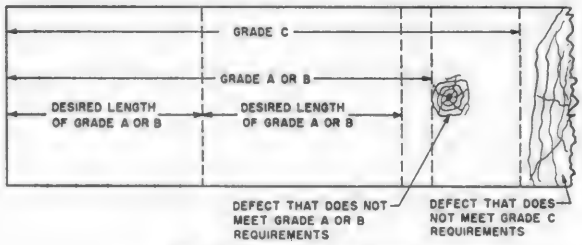
GRADE C
GRADE A OR B
DESIRED LENGTH OF GRADE A OR B
DESIRED LENGTH OF GRADE A OR B
DEFECT THAT DOES NOT MEET GRADE A OR B REQUIREMENTS
DEFECT THAT DOES NOT MEET GRADE C REQUIREMENTS

Fig. 2.—Marking procedure.

Table 1.—YIELDS BEFORE KERF LOSSES

Planer Ripping Width (in)	Total Rough Lumber Analyzed (bd ft)	Grade	Yield (bd ft/MR*)	Shook Length (in)	Band-Rip (bd ft/MR)	Yield Including Band-Rip (bd ft/MR)
2	445	A	820	6	2	788
				12	0	748
				18	0	665
4	445	A	834	6	16	787
				12	11	702
				18	9	667
6	776	A	825	6	15	775
				12	14	701
				18	10	561
		B	838	6	22	818
				12	19	767
				18	14	746
		C	863	--	--	---
8	892	A	767	6	59	725
				12	50	594
				18	38	471
		B	803	6	64	762
				12	49	716
				18	34	585
		C	905	--	--	---

*Board feet per thousand board feet rough lumber.

4. Cutting Procedure: If the actual mill cut-off method had been followed, in which several kinds of shook are sawn from each board, it would have been necessary to analyze the sample for a large number of different combinations of different grades and lengths of shook. Therefore the yield of just one length and grade was estimated at a time.

First, the whole sample was analyzed to determine how many board feet of a certain grade of one length it contained. Next, the same procedure was followed for another size and grade. In this way the total board feet of each length and grade from each board width were obtained and tabulated. Comparison of these yields gave a measure of the relative availability of the different kinds of shook from the different widths of boards.

5. Kerf: The volume of wood that would be removed in sawing the lumber into shook of different widths and thicknesses was calculated and subtracted from the theoretical yields (yield before kerf).

It was not intended that the analysis would give positive information on shook yields for all box lumber sawn in the west. It was meant, rather, to give *comparative* data of the effect of different variables on yields. This approach provided a relatively quick and simple means of obtaining the information desired.

Description of Analysis Results

A sample of 2,000 board feet of 3, 4, and 5 Common ponderosa pine was assembled by the representative mill from three different sources. The original boards were about 1½-in. thick and 12-in. wide. In order to take into account the effect of various widths on shook yields, these were ripped into 2-in., 4-in., 6-in., and 8-in. width.[3]

The boards were then marked for flaws, under the direction of an experienced mill operator, and photographed (Fig. 1). The photographs were enlarged to scale 1 in. = 1 ft and these enlargements were used in the remainder of the analysis. This use of scalded photographs rather than the actual lumber provided a quick and convenient method of analysis.

Three grade requirements were chosen. These, representing high, medium, and low grade shook, were as follows:

Grade A could contain no defect other than sound red knots ½ in. in diameter and smaller.

[3] 2-in. boards were not actually sawn. Rather, the photographs of the 4-in. boards were marked to simulate ripping into 2-in. widths.

Grade B allowed sound red knots up to 2 in. and black knots up to ½ in. in diameter.

Grade C would contain sound red knots up to 3 in. and black knots up to 1 in.

Since pitch and stain do not weaken lumber, they were not considered defects.

The photographs of the lumber sample were then marked to simulate cut-off and band rip cuts that would be made to remove the defects not allowed in each grade (Fig. 2). The pictures of the 2-in. and 4-in. boards were not marked for Grades B or C since it was felt that a knot 2 inches or larger, in a 2-in. or 4-in. board, would make it unusuable as shook.

The yields of 6-in., 12-in., and 18-in. lengths of the grades for which each set of board width pictures was marked was then obtained by determining the number of pieces that were available in the length between defect cuts (see Fig. 2). As an example, if there was a distance of 19 inches between two defects cuts, it was said that it would yield three 6-in. pieces, one 12-in., or one 18-in. Admittedly, cutting one 12-in. piece could also give a 6-in. length of the same grade. However, for the sake of simplicity this remainder was considered waste. The results of these measurements are shown in Table I.

Kerf losses were estimated by calculating them as the volume of wood that would be removed from the theoretical yields of any length and grade as determined from the photographs. This footage was subtracted from the board feet available before ripping and resawing (as determined from the pictures) to give the net yield of shook of any size.

Results

The data obtained in the analysis are discussed in four parts. These cover the effects of board width, grade, shook lengths, and saw kerf on the yield of shook from the rough lumber sample.

A. Board Width: The term "board width" as used here means the width of boards that are planed, ripped and sent to the cut-off saws.

When a defect is cut out of a board, some sound wood on one side of the flaw may be lost. This wood might have been saved and a long piece cut from the sound side if the board had been ripped into narrower widths, only one of which contained the defect. This is confirmed by the analysis (see Fig. 3 and Table I). 2-, 4-, and 6-inch boards yielded about the same amount of grade A shook 6 inches long, while 8-inch boards yielded somewhat less. As shook length increased, yield fell off with wider boards.

B. Shook Grade: The effect of grade on shook yield can be seen in Fig. 4 and Table I. There was little difference in the yield of the different grades from 4-in. and 6-in. boards. However, the yields of grades A and B were lower from the 8-in. boards, while the grade C yield was higher.

C. Shook Length: The effect of shook length on yield was much more marked than the effect of grade. This is shown in Figs. 3, 4, and 5, and Table I. When all the wood available as both long and short pieces is considered, shook grade has little effect on yield. However, yield decreases as shook length increases, and decreases more rapidly for higher grade shook than for low.

D. Kerf: Losses due to saw kerf are not large compared to defect losses, except when thin or narrow pieces are sawn. An example of this is

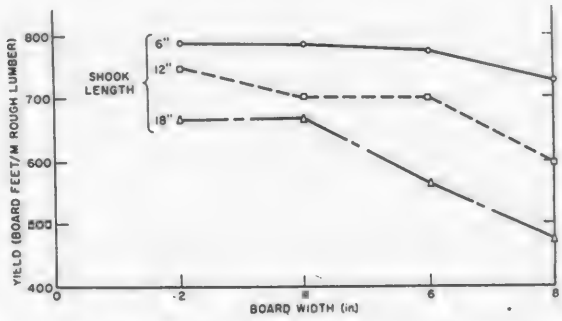

Fig. 3.—Effect of board width on Grade A yields.

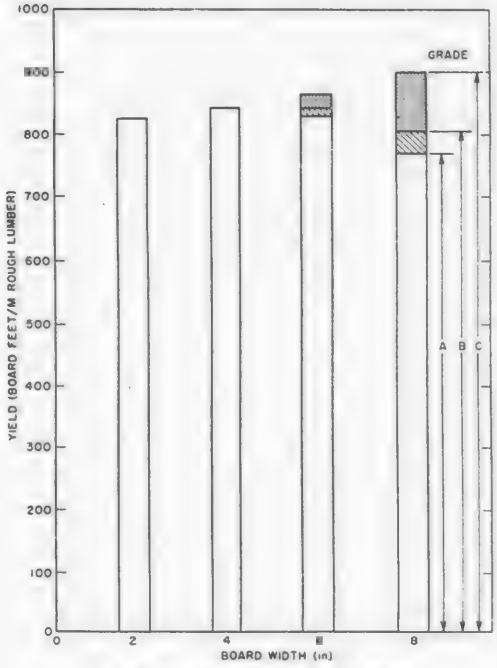

Fig. 4.—Effect of grade on yield.

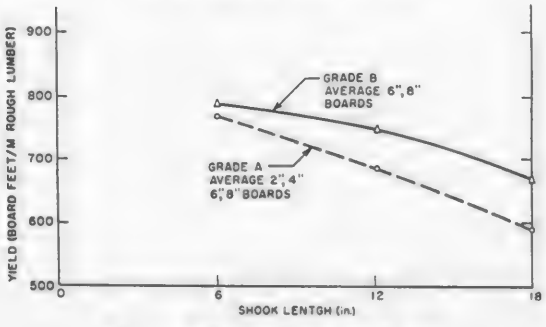

Fig. 5.—Effect of shook length on yield.

Table 2.—YIELDS LESS KERF LOSSES* (bd ft/MR)

Thickness (in)	Grade	Shook Length (in)	Width (in) 5/8	1 3/8	1 7/8	2 7/8	5 7/8
3/32	A	6	---	---	446	---	---
		12	---	---	404	---	---
		18	---	---	325	---	---
	B	6	---	---	471	488	505
		12	---	---	443	459	475
		18	---	---	430	445	461
1/4	A	6	573	605	605	---	---
		12	519	548	548	---	---
		18	415	436	436	---	---
	B	6	---	---	634	651	668
		12	---	---	598	614	630
		18	---	---	583	598	614
23/32	A	6	668	700	700	---	---
		12	604	633	633	---	---
		18	483	507	507	---	---
	B	6	---	---	740	757	774
		12	---	---	693	709	725
		18	---	---	674	689	705

*Based on actual dimensions.

shown in Table II and in Fig. 6 for 1 7/8-in. x 12-in. grade B shook. When 3/4-in. x 1 7/8-in. shook is sawn, kerf loss is about two-thirds as much as defect loss (wood that does not meet grade C requirements). When it is cut to 3/8-in. thickness, kerf loss roughly equals defect loss, and when resawn to 1/8-in. it is nearly three times as great.

Summary

A method of determining the effects of board width and shook grade and length on the yields of wooden box shook has been developed and applied to a sample of ponderosa pine box lumber. The results of the analysis show the yields of 6-in., 12-in., and 18-in. shook, of different representative grades, from 2-in., 4-in., 6-in., and 8-in. boards. The following general conclusions can be drawn:

1. Shook yields from boards 2 inches and 4 inches are about the same. However, the yields from 6-inch boards are less, and from 8-inch boards still lower.
2. Overall yields (including pieces of all lengths) are not greatly affected by shook grade.
3. Yield decreases with shook length. The rate of decrease is affected by grade—the yield of long, low grade pieces being higher than that of long, high grade.
4. The effect of kerf on the yield of thin and narrow pieces is high compared to other losses.

The analysis was based on a small sample, and some of the methods did not conform to shook mill practice. However, it is felt that the results give some indication of what might be expected in an average operation.

Common sense might have revealed some of these things, but not in quantitative form. Before this analysis, it was not known, for example, whether the yield of pieces 18 inches long was almost the same as that of 12-inch, or only half as great. The analysis gave at least some quantitative idea of the effect of different variables on the amount of shook that could be sawn from a given amount of rough lumber.

This paper is not intended to supply data upon which shook mill operation can be based or boxes designed. It is intended, rather, to present a fairly simple method for estimating the effects of certain variables on the shook yields and gives the results of the application of this method to a sample of rough box lumber.

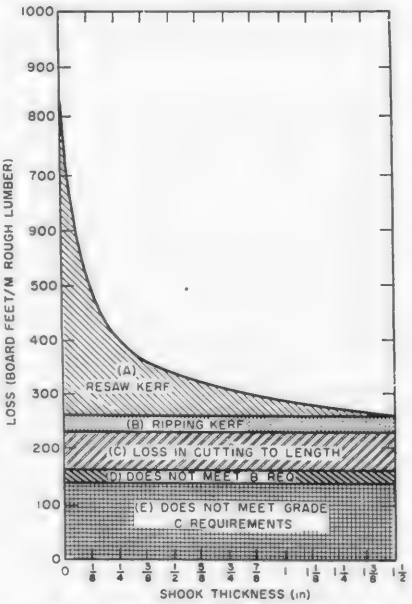

Fig. 6.—Effect of shook thickness on losses (1 7/8-in. by 12-in. Grade B shook sawn from 6-in. boards).

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FPRS CUMULATIVE INDEX 1947-1955

Title and Subject Index

This index lists all articles published by the Forest Products Research Society since its founding in 1947. Included are all PROCEEDINGS of National Meetings, beginning with the first in 1947, and all issues of the JOURNAL, from Vol. I, No. 1 in September 1951 through Vol. V, No. 6 in December 1955. Volumes I through IV were known as JOURNAL OF THE FOREST PRODUCTS RESEARCH SOCIETY; Vol. V, No. 1 was the first under the present name of FOREST PRODUCTS JOURNAL.

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How To Use the Index

If the exact title or an author's name is known, an article can be quickly located. If neither the title nor author's name is known, there are many clues by which an article can be found. For example, an article on "Durability of Fortified Urea-Resin Glues in Plywood Joints" can be found under Glues and Gluing, Plywood, and Urea Resin.

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Abstracts From Current World Literature

Waste Utilization

Heaps, J. M. How sawmill chips are handled at Ocean Falls. *Paper Trade J.* 139 (20): 24–6 (May 16, 1955).

Screened Douglas-fir chips from sawmill and plywood waste produced at the Fraser Mills plant of Canadian Western Lumber Co. are loaded into hulks and towed to Ocean Falls, B.C., 350 miles north, where they are unloaded approximately 1400 feet from the kraft mill digester bins. A derrick with a 6-cu.-yard capacity chip bucket lifts the chips from the hulks and dumps them into a steel-lined hopper on the wharf; from here they are conveyed by a pneumatic system either to the mill bins or to an open storage pile where they may be reclaimed as needed. For the return trip to Fraser Mills the hulks are loaded with high-grade logs. At present a blend of approximately 50% Douglas-fir chips and 50% chips from hemlock and other species is used; it is hoped that 70% Douglas-fir chips will eventually be reached. Arching and packing together in solid masses of the Douglas-fir chips in the conveyor system were overcome by constructional improvements; the system is now operating satisfactorily. [Bul. Pap. Chem. V. 25, No. 10]

Kozmal, F. Fluidization in waste wood industry. *Paliva* 34, 250–1 (1954).

The pyrolysis of sawdust, and of sulfate black liquor residue, the reduction of Na_2SO_4 to Na_2S, and the oxycellulose processes are discussed. [Chem. Abs. V. 49, No. 13]

Wood Chemistry

Kalnins, A. and Ozols, O. Semicontinuous method of dry distillation in vertical retorts. *Voprosy Lesokhim. i Khim. Drevesiny, Trudy Inst. Lesokhoz. Problem, Akad. Nauk. Latv. S.S.R.* 6, 3–17 (1953).

By substituting internal for the external heating used with vertical retorts in wood distillation, the anticipated increases in efficiency and in productivity were realized, but the cost for fuel was excessive and conditions in the condensing system were unsatisfactory. Heat losses indicated that these two defects might be remedied by converting the batch process into a semicontinuous operation. This was attained by operating a block of four retorts with a common, combined fire box, the heat direction from which was periodically varied, by means of a rotating commutator and a series of valves, so that the four steps, drying, heating, destructive distillation, and cooling followed by discharge and recharge, were proceeding in all four retorts, but at a different stage in each retort. The pilot plant, in addition to the block-of-four vertical retorts with combined fire box and commutator, contained scrubbers, cooling devices, condensing system, ventilator, and recuperator. The normal time for a working cycle was four hours. Comparison of the results from the two types of pilot plant with results from an externally heated Minsk retort showed that the block-of-four retorts with combined fire box is three times as efficient as is the retort with internal heating, and 2.3 times as efficient as a Minsk retort operating under optimum conditions. In the block-of-four retorts with combined fire box, less heat-resistant steel is needed for the recuperator; dimensions of the condensing system are smaller; less cooling water is needed; and a larger range of materials can be dry-distilled successfully. [Chem. Abs. V. 49, No. 9]

Chemical Debarking

Berntsen, Carl M. Some results of chemical debarking on Sitka spruce, western hemlock, and red alder. U. S. Dept. Agr., Forest Service, Pacific Northwest Forest and Range Expt. Sta. Research Note no. 104. (Sept., 1954).

Tests on the chemical debarking of the three species with sodium arsenite, sodium monochloroacetate, borate, chlorate borate, and a mixture of 2,4-D and 2,4,5-T are reported. Sodium arsenite, when painted on a sap-peeled girdle on spruce and hemlock during the growing season, loosened the bark sufficiently to allow peeling of large sections the following year. Increased breakage of treated trees during falling may be of some concern, however. The other chemicals showed little or no effect, and continued tests in the form used seemed unwarranted. Red alder bark showed the least response to chemical treatment despite the several types of treatment used. Prospects for successful chemical debarking of spruce and hemlock using sodium arsenite seem encouraging, and techniques to make the bark slough off before or during logging merit further investigation. Meanwhile, the sodium arsenite treatment may have limited application in facilitating manual bark removal and thereby extending the sap-peeling season. [Bul. Pap. Chem. V. 25, No. 10]

Insect Damage

Schmidt, H. Forms of termite attack on plywood, chipboards and fibreboards. *Holz Roh-u. Werkstoff* 12 (2), 1954 (44–6).

Describes the methods of attack and the appearance of damage done by *Reticulitermes* to Beech plywood (Kaurit glue with blood albumen), chipboards (Spruce chips with urea-resin glue), and Spruce fibreboards. Full protection (coating and deep impregnation) with phenol-formaldehyde resin glues or with repellents is recommended. [For. Abs. V. 16, No. 2]

Forest Genetics

Lannan, P. T., Jr. Industry's part in forest genetics. *Tappi* 38 (4): 146–8A (April, 1955).

The author discusses the significance of forest genetics with emphasis on the possibility of obtaining certain immediate results. The support of industry is stressed to speed research and to develop early answers to some problems. Custom growing of seedlings from seed collected from superior trees is listed as an example of what forest genetics can accomplish. [Bul. Pap. Chem. V. 25, No. 9]

Wood Supply

Allen, B. E. Conservation practices in connection with wood procurement. *Tappi* 38 (4): 144–6A (April, 1955).

The author reviews the efforts and accomplishments of the southern pulp and paper industry for bettering the source of supply of their raw material and insuring its existence over the years to come. A comparison of the surveys made by the U. S. Forest Service in 1934–35 and repeated in the period from 1947 to 1953 shows that there is approximately as much timber by volume growing in South Carolina, Georgia, and Florida today as there was in the mid-thirties, despite the tremendous growth and expansion in the pulp and paper industry and the enormous drain imposed by the lumber industry during the war years and postwar building boom. [Bul. Pap. Chem. V. 25, No. 9]

Godwin, Gordon. How are you fixed for wood? *Pulp Paper Mag. Can.* 56 (4): 115–16, 118, 121 (March, 1955).

The author summarizes the present situation concerning the present and future supply of wood for the Canadian pulp and paper industry. The industry uses 22% of all the wood taken from the forests each year. It has been established that at present cutting rates there is a sufficient supply of wood to run the pulp and paper industry forever, and except for white and red pine, to last all the forest industries forever. The work of the industry in providing protection from fire and insects, finding uses for waste products, regeneration, and providing more and better trees is reviewed. [Bul. Pap. Chem. V. 25, No. 9]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiber board and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham, Royal, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains about 1,200 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

FPRS News-Digest, Continued

Northeast Meeting

(Continued from page 20–A)

95% providing for the future. There is no magic about applied research. The small company would do well to investigate it and proceed to develop data from any of the following sources: (1) the wealth of fundamental research results already available in printed form; (2) sales representatives of suppliers, their catalogs and bulletins; (3) trade and professional organizations; (4) the Forest Products Research Society; (5) government research organizations such as the Forest Service, Department of Commerce, Bureau of Census; (6) Small Business Administration; (7) colleges; (8) trade magazines and books; and (9) the independent laboratory or consultant."

The magnitude of research in the U. S. is difficult to assess, C. G. Fick of the General Electric Co. said in a luncheon address. Speaking on "An Industrial Research Laboratory's View of the Advancing Field of Science," Fick said that the 1955 rate of expenditure for research was $4.2 billion. Fick estimated the number of scientists to be between 180 to 225 thousand, and stated that 2,845 out of 300,000 plants have research departments. G. E., for example, has 600,000 square feet of laboratory floor space, and 1,600 persons working on research, he said.

Mid-South Section, November 7–8

In Memphis, Tenn., forest products researchers concentrated on utilization of hardwoods and merchandising.

J. J. Copeland, Wood Procurement Manager, Masonite Corp., Laurel, Miss., said, "The year 1955 has seen amazing advances in the field of hardboard waste utilization. My company feels that we are only at the threshold of developments that will revolutionize the economics of all branches of our industry. In the veneer industry, up to 50% of the original log is potentially recoverable for chip wood. Today many veneer plants have brought waste recovery to a total of 40% of the log."

James R. Welsh, Welsh Plywood Corp., Memphis, Tenn., speaking on the need for greater merchandising in the lumber industry, de-emphasized the role of more advertising in favor of a greater program to enable the 150 million people of our nation to purchase wood readily, in a usable form, at a reasonable price, and one that will not be shrouded in mystery. Portable tools, love of the "Do-it-yourselfer," have risen from a volume of $6 million in 1948 to $95 million in 1953 and created a vast new market. Welsh also recommended improvements along the lines of (1) dispelling ignorance within the wood industry about the size of markets, (2) removing mystery surrounding consumer wood definitions—come up with uniform consumer grading standards, and (3) think of "packaging" our product, along with more point-of-sale and self-service. "Remember," Welsh continued, "the whole objective of merchandising is to make it easier for people to buy."

Stanley Horn, Editor of Southern Lumberman and dinner speaker at the Memphis meeting, reviewed the role of research in forest products progress over the past several decades. Noting great improvement in processes and products, he cautioned against defeatism and urged continual application of fundamental research toward new uses for wood. "We are at the threshold of a new era in forest products," he concluded.

Northern California Section, October 28

At Antioch, Calif., in the heart of the western pine and redwood industries, FPRS men continued in the same vein.

W. B. Lindberg, Fiberboard Products Inc., emphasized the economics of waste wood utilization. "In the past few years, due to new and better chippers and barkers, the lumber mill waste wood usage of our firm has increased from 30% to 75% of our total raw material requirements. It is interesting to note reports from sawmills operating debarkers which indicate increases in lumber production of 5% to 10%, higher grade recovery, and substantial savings in saw life and mill cleanup."

Ohio Valley Section, October 13–14

At Louisville, a shift toward concentration of the wood industry in larger firms in the next 20 years was predicted by C. D. Dosker, president of Gamble Brothers, Inc. Board lumber will be a by-product of fiber operations, causing this greater concentration, according to Dosker. He pointed out that such concentration will result in better quality products at stable prices.

New wood products will be developed through research and thus increase wood use—a factor not taken into account in the Stanford Report, asserted Dosker, who moderated a panel discussion on the Stanford Research Institute Report. Increased funds for forest products research are essential for growth of the industry, however. The pulp and paper industry, which accounted for four-fifths of money spent for forest products research in 1953, has doubled in size by meeting its problems through research, it was pointed out.

Chipcore has given the wood-using industry a new weapon to work with in retaining present markets and regaining lost ones, Carl Seng, Production Manager of Jasper Desk Co., Jasper, Ind., told the Ohio Valley meeting. Describing problems his firm has overcome in using chipcore, Seng called for the industry to exchange knowledge and ideas on all its problems through organizations such as FPRS. "The entire industry will progress," he said, "if we correct the past mistake of keeping our doors and windows locked to other firms in the same industry."

Florida–Georgia–Alabama Section, Nov. 17 and 18

And in the deep south, at Gainesville, Florida, Forest Products Researchers had this to conclude:

Educating consumers to the value of properly treated lumber is the key to the greatest development of not only the wood preserving industry but the lumber industry as well, according to O. W. Boehm, vice-president, Dantzler Lumber and Export Co., Jacksonville, Fla. Boehm predicted that extended use of properly treated wood will play a major role in recapturing an appreciable percentage of business which has been lost to nonwood substitutes. One of the most bedevilling claims of substitutes is durability, he pointed out, and the wood industry must assume that the consumer is willing to pay a reasonable price for a product that will insure improved durability.

The recent rapid development of comparatively small, independent treating plants will result in an integrated force to meet the problem of distribution in the preserving industry—a problem which has long been one of revolving concern. These plants, serving the light construction industry, have the greatest market potential in the history of the preserving industry, Boehm told the group. As the prospective growth of these plants continues, he added, the public will certainly accommodate them with a persistent demand for properly treated products.

W. C. Hammerle, Executive Secretary of Southeastern Pine Marketing Institute, told the F–G–A meeting that lost markets can and will be

recaptured by establishing quality standards of wood products and convincing buyers that good lumber is worth its price. Hammerle pointed out that Southern pine producers could assure the future of their business and the permanence of their markets by organizing in the marketing group. Organization will assure consistent performance of product quality and dependability, Hammerle said, and the merchandising effort needed to create increased demand in a highly competitive market.

Barking Discussed at Pacific Northwest Section

Log barking equipment was a featured topic at the fall meeting of the Pacific Northwest Section Oct. 24–25 in Vancouver, B. C. Section Secretary-Treasurer R. W. Wellwood furnished the following report of the meeting to the FPRS Executive Office. Attendance at the meeting included 79 members and 65 non-members.

R. W. Wellwood

The first day was spent on a tour of five plants, to illustrate the principal types of sawmill log barkers in use in the area. These included the Hansel spinning ring barker, Eburne Saw Mills Division, Canadian Forest Products Ltd.; Bellingham barker, Bridge Lumber Co., Ltd.; Simons rotary-head barker, Canadian White Pine Division, MacMillan and Bloedel Ltd.; Hansel oscillating barker, Alaska Pine Division, Alaska Pine and Cellulose Ltd.; and Nicholson mechanical roto-barker, Pacific Pine Co., Ltd.

The dinner speaker was R. H. Edgett, Assistant Sales Manager, Seaboard Lumber Sales Co., Ltd. He discussed the problems of exporting lumber from a great distance into the large United Kingdom markets, in competition with Baltic timber manufactured nearby. The U. K. market has gone through a period of wartime controls, post-war restrictions on purchase and use, and has eventually been freed of controls. The customer has been schooled to an economy of timber shortage and the desirability of using substitute materials wherever possible. In addition to these handicaps, there are many unrealistic restrictions on the use of wood in building. The problem is one of education and demonstration, and of meeting exacting standards of manufacture.

Factors affecting the selection of a sawmill log barker were discussed by a morning panel on the second day. This discussion is being edited for later publication in the JOURNAL. The panel agreed that barking reduced saw costs, and increased overrun by an undetermined but small amount. Grade recovery was improved and pollution is not yet a problem. Mill output is improved, and the mill is cleaner. Each mill has its own problems to consider in selecting a satisfactory log barker.

During the afternoon technical session, three papers were presented. Don Burnet, Safety Engineer, Pilot Rock (Ore.) Lumber Co., discussed "The Application of Statistical Quality Control in the Sawmill". Data originated from studies conducted by the Oregon Forest Products Laboratory in several small mills. Thicknesses of five boards from the headsaw were measured daily in each mill, at five fixed places on the board. Control limits must be selected by experience since there is no standard of exact thickness for green boards. The speaker illustrated the value of the measurements in reducing the average oversize in thickness and the spread or range about the desired green thickness.

J. L. Zeigler, General Manager, Western Nu-Ply Corp., South Bend, Wash., spoke on "Nu-Ply—The Modern Approach to Wood Panel". This panel, developed by the Elmendorf Research Laboratories, consists of a fiber hardboard core, overlaid with 1/64-inch green veneer faces. The panel face is smooth as it comes from the press and is buffed with fine grit paper to give it a surface that is easily finished. It can be punched, die cut, drilled, and glued much like hardboard. Average specific gravity is 0.95, modulus of rupture is 9,000 psi perpendicular to veneer grain and 3,750 psi parallel to veneer grain.

The final paper was "Suspension Drying of Wood Particles", by S. C. Corder, Mechanical Engineer, Oregon Forest Products Laboratory, Corvallis. The speaker described the system developed at the Oregon laboratory for this type of drying where the particles are conveyed in an air stream and simultaneously dried. Moisture is removed in a cyclone. Contact of the particles with the heat source is short (1–10 sec.) and the temperature high (1,500° F.) The same general principle is used to dry starch, coal, lignite, Presto-log material, and to some extent material for particle board plants. Interest is being shown in pre-drying wet fuels (i.e. bark, hog fuel).

A film was shown of an English bandsaw mill designed for cutting of small logs, following which Section Vice-Chairman John R. Stillinger presided at a short business meeting. Membership Chairman Earl T. McCarthy reported a current Section membership of 444, and other Section affairs were discussed.

New Officers Elected by Seven FPRS Sections

Seven FPRS Sections announced the election of new officers and trustees during the fall of 1955. The thirty-five newly elected are:

Mid-South Section

Chairman, Robert M. Boehm, Director of Research, Masonite Corp., Laurel, Miss.; Vice-Chairman, D. M. Fisher, Jr., Southern Lumber Co. Warren, Ark.; Sec.-Treas., John Wells, Wells Furniture Mfg. Co., Laurel, Miss.; Trustees: H. E. Bovay, Jr., Consulting Engineer, Houston; Mark M. Lehrbas, Southern Forest Experiment Station, New Orleans; Arthur W. Nelson, Jr., The Flintkote Co., Meridian, Miss.

Carolinas–Chesapeake Section

Chairman, John Colucci, Jr., Southern Box & Lumber Co., Wilmington, N. C.

Ohio Valley Section

Chairman, Carl Seng, Production Mgr., Jasper Desk Co., Jasper, Ind.; Vice-Chairman, R. H. Elliott, Standard Dry Kiln Co., Indianapolis; Sec., Lee Eberhardt, Bauer Bros. Co., Springfield, Ohio; Treas., Paul J. Fenn, Tell City Chair Co., Tell City, Ind.; Trustees: Sterling Durst, Gamble Bros., Louisville, Ky.; J. H. Wilson, Wilson Brothers, Indianapolis.

Midwest Section

Chairman, L. J. Fitzpatrick, President, J. J. Fitzpatrick Lbr. Co., Madison; Vice-Chairman, J. J. Allegretti, Masonite Corp., Chicago; Sec., D. W. Bensend, Dept. of Forestry, Iowa State College, Ames; Treas., W. A. Kluender, C & NW Railway System, Chicago; Trustees: J. C. Caresio, Masonite Corp., Chicago; H. J. Gill, Jr., Carr, Adams & Collier, Co., Dubuque; W. C. Lewis, U. S. Forest Products Lab.

Florida–Georgia–Alabama Section

Chairman, Prof. J. B. Huffman, School of Forestry, Univ. of Florida, Gainesville; Vice-Chairman, E. M. Conway, U. S. Forest Service, U. of Georgia, Athens; Sec.-Treas., L. F. Rand, Florida Furniture Industries, Inc., Palatka; Past Chairman, D. B. Richards, Forestry Dept., Ala. Polytec.

FPRS News-Digest, Continued

Inst., Auburn; Trustees: Bruce E. Anderson, 3630 Peachtree Road, Atlanta, N. E.; D. W. McConnell, Pres., Coosa Charcoal Co., Birmingham, Ala.; C. L. Brice, Brice Lbr. Co., Archer, Fla.; Julian F. McGowan, W. C. Smith Lbr. Co., Chapman, Ala.

Upper Mississippi Valley Section

Chairman, Howard Olson, Chapman Chemical Co., St. Paul, Minn.; Vice-Chairman, Henry C. Crandall, Mosinee Paper Mills Co., Mosinee, Wis.; Sec., W. B. Wallin, School of Forestry, U. of Minnesota, St. Paul; Treas., P. H. Lane, Forest Utilization Div., Northern Lakes Forest Research Center, Wausau, Wis.

Great Lakes Section

Chairman, S. B. Preston, Head, Dept. of Wood Technology, U. of Michigan; 1st Vice-Chairman, G. G. Garlick, Protection Products Mfg. Co., Kalamazoo, Mich.; 2nd Vice-Chairman, Fred Atkinson, Perkins Glue Co., Grand Rapids; Sec., S. W. Tamminga, V. P., Hekman Furniture Co., Grand Rapids; Treas., E. B. Applegate, Travis–Applegate Co., Grand Rapids.

1956 Wood Award

(Continued from page 16–A)

be presented at the FPRS 10th National Meeting in Asheville, N. C., June 4–7.

The awards this year will be confined to graduate students working toward Master's or Doctor's degrees. The first place winner will receive $350 and second place, $150. The first place winner will also be encouraged to present his paper at the Asheville meeting.

Subjects for entries may be any which make a fundamental or practical contribution to the industry in research, development, production, utilization, or marketing. Papers should be based on research projects completed after May 1, 1955, and prior to May 1, 1956.

Notice of entry should be submitted at the earliest possible date to the Executive Office of the Forest Products Research Society, Box 2010, University Station, Madison 5, Wis. Tentative titles should be received at this office not later than April 15. Administrator of the award is the FPRS Industry-Education Committee, chairmanned by Dr. Alexis J. Panshin, Head, Department of Forest Products, Michigan State University, E. Lansing, Mich.

Wood and Wood Products Award winners in recent years have included men who have risen to prominent positions in the wood industry. Among these are: Nicholas V. Poletika, recently named Director of Research at Teco; Charles R. Morschauser of the Teco staff; S. B. Preston, Head, Department of Wood Technology, School of Natural Resources, U. of Michigan; and most recently, Ben A. Jayne, staff, Yale University School of Forestry.

National Adhesives Gives 11 FPRS Memberships for Christmas

Eleven persons received Christmas gift memberships in FPRS for 1956 through the courtesy of National Adhesives Division of National Starch Products Inc. They were notified of the gift by a greeting card reading: "It is fitting as we observe the Yuletide Season, drawing this year of peace and prosperity to a close and looking ahead to a prosperous New Year, that the National Adhesives Company, in appreciation of its enjoyable association with your company, has entered your name as a 1956 member of the Forest Products Research Society. Mem-

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bership will entitle you to all attendant benefits, including the highly regarded monthly 'Forest Products Journal'."

Receiving the memberships were: Chuck Crawford, Daystrom Furniture Co., Alma, N. C.; Mel Kayne, York Plastics Products, Brooklyn; Tracy Hitchner, Century Furniture Co., Hickory, N. C.; William Martin, Wisconsin Door Co. of N. J., Newark, N. J.; Michael Berger, Artcraft Sink Top, Springfield Gardens, N. Y.; Stanley Biskup, B. Brody Seating Co., Chicago; Norman Thule, Lloyd Mfg. Co., Menomonee, Mich.; Mr. Clark, Gluck Bros., Morristown, Tenn.; K. Tompkins, National Homes Corp., Horseheads, N. Y.; W. Bull, The Stanley Corp., Stanley, Wis.; and Henry Pettus, Southern Wire & Iron Works, Atlanta, Ga.

Join in Program to Give Summer Jobs to Students

Wood-using firms are urged to participate in the FPRS Summer Employment Service by offering summer jobs to forestry and wood technology students. Firms are now being contacted through regional representatives on the Employment Committee, according to Newell A. Norton, chairman. Those wishing to participate may also write to their regional representative, listed below.

Through the service, the student is furnished the names of firms cooperating in the program, with the student then assuming the responsibility for obtaining his own summer job. Forestry schools throughout the country have been contacted through an employment representative, who must designate by February 1, 1956, whether his school wants to utilize the service.

Committee members are: Harvey H. Smith, P. O. Box 245, Berkeley 4, Calif.; Prof. A. E. Wackerman, Duke University, Box 4744, Duke Station, Durham, N. C.; Dr. Frank H. Kaufert, School of Forestry, U. of Minnesota, St. Paul; Richard W. Petterson, R. F. D. 2, Box 466 A, Gig Harbor, Wash.; Dr. E. R. Martell, Dept. of Forestry, Purdue University, Lafayette, Ind.; E. A. Behr, Chapman Chemical Co., Mallory Station, Box 3158, Memphis, Tenn.; and Chairman, Newell A. Norton, School of Forestry, Penn State University, University Park, Pa.

Koch Research Conducted At Washington College

The article by Peter Koch on "An Analysis of the Lumber Planing Process: Part I," in the August FOREST PRODUCTS JOURNAL should have credited the College of Forestry, University of Washington, Seattle, as the site of Koch's research. The article was based on a dissertation submitted in partial fulfillment of the requirements for a Ph.D. degree at the Washington College.

INDUSTRY NEWS

Bodine Gives Optimistic 1956 Outlook for Lumber

The lumber outlook for 1956 is optimistic when all the factors that make for prosperity and a high level of business activity are considered collectively and individually, according to Leo V. Bodine, executive vice-president of National Lumber Manufacturers Assoc.

Lumber production in 1955 is estimated at 38.5 billion board feet, 5 per cent above 1954 and the highest since 1916. A continuation of high production and use in 1956 is predicated, among other things, on its being an election year in which the Administration is expected to do all it can to keep construction at a high level.

Estimates by the Bureau of Labor Statistics and NLMA are for approximately 1.2 million housing starts next year, which could mean a market for some 12 billion board feet of lumber. Cost of all new construction in 1956 is predicted at $44.1 billion, or 6 per cent over the record $41.8 billion estimated for this year.

Commercial and religious building are among non-residential construction classes expected to register an increase over 1955. The trend to suburban living is spurring the shopping center boom, which means new lumber markets on several different fronts. Engineered timber construction featuring solid and glued laminated members is proving increasingly popular for churches, schools, supermarkets, factories, and other one- and two-story structures. On the residential building scene, wood continues as the most advantageous material in contemporary homes.

Other factors influencing lumber prospects for the coming year include: the continually growing number of do-it-yourself enthusiasts; the higher minimum wage going into effect March 1, which may force some marginal operators out of business; increased military lumber purchases by the Corps of Engineers, expected to total 510 million board feet; and less being spent for farm building and maintenance work, with farm income down. Lumber has always been the most popular building material among farmers, however, and with farm income off, lumber's economy will give it an ever greater edge in farm building plans.

Bolstering the general confidence of U. S. business and industry are the prospects of a balanced budget and tax reduction in the near future. In sum, there appears just cause for optimism about the future and the year ahead for the lumber industry, Bodine concludes.

Tone of Optimism Indicated By Timber Resources Review

Encouraging gains in the country's timber supplies are indicated in the findings of a 3½ year review recently released in preliminary draft form by the U. S. Forest Service. The first official report on the Timber Resource Review was given by Richard E. McArdle, Forest Service Chief, at the annual meeting of the Society of American Foresters. The nine-chapter report is now being reviewed by state and private cooperators

Highlights of the report, which justify a tone of optimism, indicate that a total of 489 million acres of commercial forest land is available for meeting timber needs, an increase of 28 million acres since 1945. The increase is accounted for by the inclusion of data for coastal Alaska, more accurate estimates, and reversion of farm land to commercial forest. The figure does not include interior Alaska, which has a commercial forest area equal to Oregon and Washington and 60 per cent as much sawtimber.

Timber growth is up 9 per cent since 1944 and, even more significantly, in the East overall growth increased 14 per cent. Growth of sawtimber is now only 3 per cent short of consumption, an improvement over 1945 when growth fell 12 per cent below the cut. Considering the country as a whole, overall growth of wood exceeds the present cut by about 33 per cent.

The Review estimates future timber demands in terms of an assumed U. S. population of 275 million by the year 2000. A minimum estimate of timber demand by that year is 67 per cent higher than 1952. A more optimistic estimate, based on the assumption that wood will continue to hold its present place in the economy, places the demand at 105 per cent above 1952.

The four best possibilities for permanently adding to timber supplies, the studies show, are: reducing the non salvaged mortality loss of 10 billion board feet annually—four-fifths of which is due to insects and disease; capturing most of the 8 billion board

feet annual sawtimber growth potential from the 50 million plantable acres; improving stocking on the one-fourth of the commercial forest land which is medium or poorly stocked; and obtaining sufficiently prompt and adequate restocking on cutover areas so as to maintain their productivity.

NLMA Elects Officers, Plans 1956 Activities

L. D. Kellogg, Alexandria, La., was elected president of the National Lumber Manufacturers Assoc. at the annual meeting in November. He succeeded Judd Greenman, who became NLMA board chairman. Walter M. Leuthold, Deer Park, Wash., was named first vice-president.

New committee chairmen elected were: T. J. McHugh, public relations; and S. M. Nickey, Jr., foreign trade. L. J. Carr continues as chairman of the building trades and promotion committee.

NLMA directors voted funds to expand the association's technical assistance to builders, architects, and engineers. They authorized preparation of a "how-to-do-it" manual on recommended framing and construction details, for use by carpenters and building foremen, and publishing of additional data on the cost of wood construction vs. other building methods, for use by architects and engineers.

Special exhibits at the meeting of NLMA and its research affiliate, Timber Engineering Co., showed examples of new and improved wood products which research is developing. "Concrete boards" and "wooden bricks" were demonstrated as new products of the future. They're made by combining wood excelsior with cement, producing an efficient building block with wood's natural insulating values and the known qualities of concrete.

Equipment was shown for ultrasonic testing of wood, which may lead to automatic stress grading of lumber. The sound waves, in effect, x-ray the wood and reveal any internal defects. Ultrasonics also may have practical application in measuring the smoothness of furniture surfaces and testing glue lines.

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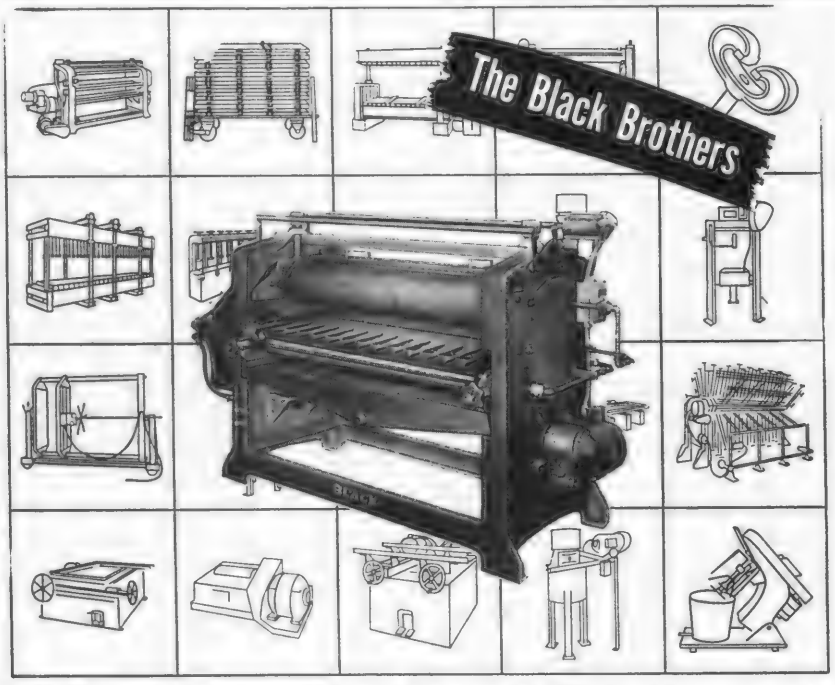

A Complete Line of Laminating & Gluing Equipment

Black Brothers manufacture a complete line of laminating and gluing equipment of nationally recognized superiority. Illustrated above is a No. 22-D resilient roll, ball bearing glue spreader equipped with water cooled doctor rolls as an optional extra for use with quick setting glues. Gluing rolls are deeply covered with fine synthetic rubber, and are specially grooved to control the amount of resins deposited and to conform to irregularities in the veneer. Accurate, heavy duty ball bearings are sealed to keep lubricants in, and dirt and glue out. Black's 22-D Spreader for resins, casein, and other cold glues is unmatched in speed, economy, accuracy, cleanliness and quality production. Write for details today . . . or let us send you a catalog on the complete Black line.

"If It Is Gluing Equipment - We Have It"

THE BLACK BROTHERS CO., INC.
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Teco Building Pilot Plant For Particle Board Development

The nation's first pilot plant for development of wood particle boards, using the advanced techniques of European manufacturers, will be constructed at the Timber Engineering Co. laboratory, Washington, D. C. The pilot plant is part of a $200,000 expansion program, the fifth and largest since Teco's establishment in 1943.

Information on European manufacturing techniques was gathered by two of Teco's top technologists, who traveled 18,000 miles and conferred with representatives of more than 100 wood-using firms and laboratories in 11 European countries. Results of this survey prompted the new pilot plant, which will enable Teco to apply European techniques to American production methods and raw materials. Carl A. Rishell, recently named vice-president, will head the particle board development.

Flexibility will be a feature of the pilot plant, being equipped to produce particle boards from all kinds of raw material — branches, slabs, edgings, chips, and trimmings. Its flaker will produce the European "educated" flake, i.e., engineered and precision cut wood particles for specific types of board, while a versatile glue mixer will turn out proper binders.

The pilot plant will have an automatic spreader and a special hot press to form resin-particle masses into

single-layer homogeneous boards, as well as into sandwich type boards, measuring up to 3 feet by 6 feet, in all feasible thicknesses and densities. The equipment is being set up as a facility for improving the particle boards of present manufacturers, and helping future producers avoid costly pitfalls in developing boards.

NAMES IN THE NEWS

Society of American Foresters Elects New Officers and Fellows

DeWitt Nelson of Sacramento, Calif. has been elected president of the Society of American Foresters for 1956–57. Director of the California Department of Natural Resources, Nelson previously served with the U. S. Forest Service for 20 years.

G. A. Garratt

Dr. George A. Garratt, dean of the Yale University School of Forestry and former FPRS President, was elected vice-president of SAF. Dean Garratt has been in forestry education for the past 35 years, having been associated with Michigan State and the University of the South before joining the Yale faculty.

Four FPRS members were among nine persons elected to the SAF Council. They were: C. H. Coulter, Florida State Forester; M. K. Goddard, secretary of Pennsylvania Department of Forests and Waters; S. G. Fontanna, dean of U. of Michigan School of Natural Resources; and H. J. Vaux, dean of U. of California School of Forestry.

Among those elected to the grade of Fellow for outstanding achievement in forestry were: Dean Fontanna; Dr. J. A. Hall, director of U. S. Forest Products Laboratory; Dr. F. H. Kaufert, FPRS National Vice-President and director of U. of Minnesota School of Forestry; and G. D. Markworth, dean of U. of Washington College of Forestry.

I. V. Anderson Retires After 35 Years in Forest Service

Announcement was made recently of the retirement of I. V. Anderson, chief, Forest Utilization Service, Intermountain Forest and Range Experiment Station. A charter member of FPRS, Anderson is widely known for his work in wood technology and timber utilization.

Anderson joined the Forest Service in 1920 after graduating from Michigan State College. Beginning as a ranger, he later served as forest examiner, assistant forest supervisor, specialist in forest products research, chief of wildlife management, and most recently as liaison between the Forest Products Laboratory and the Rocky Mountain timber industries.

Author of numerous publications on logging and utilization, Anderson worked with the War Production Board during World War II in facilitating timber production.

RESEARCH LAB of Timber Engineering Company as it will appear when its current expansion program is completed in 1956. Second stories will be added to two buildings, providing 7,000 additional square feet of floor space.

Col. William B. Greeley, Former USFS Chief, Dies

Col. William B. Greeley, 76, died November 30 in Port Gamble, Wash. He served as Chief of U. S. Forest Service from 1920–28, and more recently, for 20 years had been secretary-manager of West Coast Lumbermen's Assoc. At the time of his death he was vice-president of WCLA.

During World War I, Col. Greeley was chief of the forest section of AEF forces in France. A past president of the Society of American Foresters and chairman of the board of American Forest Products Industries, Inc., he was widely known and respected in forestry and public service circles throughout the world.

D. C. Everest, Marathon Board Chairman, Dies

D. C. Everest

David C. Everest, Chairman of the Board, Marathon Corp., Rothschild, Wis., died in November. Long interested in FPRS activities, Mr. Everest was formerly his firm's designated representative to the Society.

Mr. Everest began his career in the pulp and paper industry in 1900, starting as an office boy with Bryant Paper Co. He was general manager of Marathon from 1909–1950, when he was named board chairman. He also served as director of several other paper, machinery, and fiberboard companies.

Former president of the American Forestry Assoc., Mr. Everest received the TAPPI Gold Medal Award in 1944. He was vice-president of Institute of Paper Chemistry and former president of the American Pulp and Paper Assoc.

Teco Promotes Rishell, Poletika, and Blumenstein

C. A. Rishell

Carl A. Rishell, director of research for National Lumber Manufacturers Association and Timber Engineering Co. since opening of the Teco Laboratory in 1943, has been elected a vice-president of Teco. Appointed director of research to succeed Rishell was Nicholas V. Poletika, well-known wood technologist and specialist in wood utilization. Robert R. Blumenstein was named assistant director of research and will continue as laboratory manager.

N. V. Poletika

R. R. Blumenstein

In his new position, Rishell will direct Timber Engineering's particle board development services and facilities.

Poletika joined the Teco staff in 1948, after receiving Yale University's first Doctor's degree in forestry and wood technology. In 1948 Poletika was the first recipient of the "Wood Award", given by Vance Publishing

Corp., publishers of WOOD AND WOOD PRODUCTS magazine. His winning paper, "A New Method of Studying the Elastic Behavior of Wood," was published in the 1948 FPRS PROCEEDINGS, with the award being presented at the FPRS National Meeting in Chicago.

A member of the Teco staff since the laboratory was opened, Blumenstein initially was project manager of the hardwood research program.

SHORT COURSES

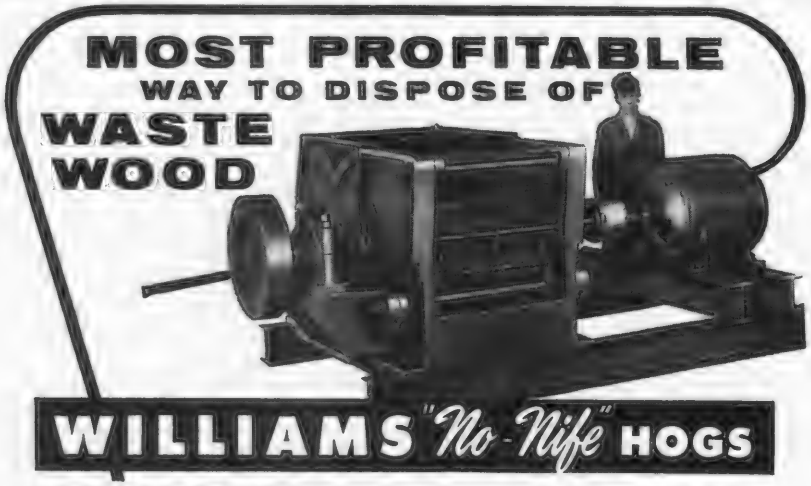
Minnesota Offering Lumbermen's Short Course Next Month

Good practices in building construction and lumber yard salesmanship and management will be featured in the University of Minnesota's annual Lumbermen's Short Course, to be held Jan. 30 through Feb. 24 at the School of Forestry, St. Paul campus. The course is sponsored by the Independent Retail Lumber Dealers' Assoc., Northwestern Lumbermen's Assoc., Hoo-Hoo clubs of the Twin Cities, and the University.

Topics covered will include public speaking, blueprint reading, drafting, building cost estimating, farm buildings, lumber yard management, and building products merchandising and use. Also included will be field trips to manufacturing plants and lumber yards.

The teaching staff will consist of 50 instructors from the U. of Minnesota, the Small Homes Council, the Forest Products Laboratory and industrial research laboratories.

Further information can be obtained from the Short Course Office, Institute of Agriculture, U. of Minnesota, St. Paul 1.



BIG MARKET FOR GROUND WOOD. Chip board and many other ground wood products offer a tremendous market for waste wood—but manufacturers of these products demand uniformity in quality and size—requirements that Williams hogs are fulfilling in dozens of plants. Whether the wood scrap you sell is in chips, sawdust or flour, a Williams will produce more, faster, with less labor, power and upkeep.

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WILLIAMS AUTOMATIC INSTALLATIONS EARN PHENOMENAL PROFITS when used for hogging and conveying wood waste to boiler or stoker—or for grinding, separating and packaging ground and sized wood.

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OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

New York College Schedules Two Industry Short Courses

Instruction in kiln drying and wood gluing will be given in two short courses offered by the State University of New York College of Forestry at Syracuse, Jan. 23 through 28.

The kiln drying course will provide information for solving individual air seasoning, kiln drying, or moisture control problems. Students will dry a full charge of lumber in the College kiln, attend lectures, discuss individual interests with College and industry specialists, and attend a clinic and open discussion of drying problems.

Subjects covered will include: structure of wood and its relation to drying; piling techniques; causes, effects, and controls of staining; insects that attack lumber; importance of proper drying to gluing of wood; types of dry kilns and their construction; moisture meters; heat and humidity; circulation and ventilation; steam systems and their efficiency; types, uses, and calibration of kiln instruments; kiln troubles and how to remedy them; drying of veneers and plywoods; and plant storage and humidification.

Gluing defects and their causes will be emphasized in the wood gluing course. The students will learn to employ production methods designed to minimize manufacturing costs and provide greater strength and durability properties to the glued product. There will also be intensive instruction in the proper selection and use of wood adhesives.

The course will cover the structure and properties of wood; selection and machining of wood; principles of gluing; wood adhesives and their characteristics; assembly gluing; cold and hot pressing techniques; radio frequency heating; testing of bond strength and quality control in gluing.

Further information on both courses may be obtained from the Forest Utilization Dept., State U. College of Forestry, Syracuse 10, N. Y.

Ottawa Laboratory Giving Lumber Seasoning Course

Procedures for obtaining high quality standards and reducing waste in lumber drying will be emphasized at the eighth annual course in lumber seasoning to be held at the Forest Products Laboratories of Canada, Ottawa, February 20–24. The course will include discussions and demonstrations of various seasoning methods.

The main subjects to be covered are: air-seasoning, kiln-drying, high-temperature drying, vapor and solvent

drying, chemical seasoning, dielectric heating, and infra-red heating. Mechanical properties and cellular structure of wood, and decay and stain in lumber will also be discussed. The course will also include visits to woodworking industries in the Ottawa area.

Applications should be addressed to the Superintendent, Ottawa Laboratory, Forest Products Laboratories of Canada, Ottawa, and should include name, position, and firm. There is no charge for the course.

FPRS News-Digest, Continued

NEW PRODUCTS—LITERATURE

Sandwich Panel

A plastic sandwich construction panel combining lightweight structural strength and insulating properties has been developed by Haskelite Manufacturing Corp., Grand Rapids, Mich. The panel is reported moisture-proof and corrosion-resistant.

New Saw Teeth

Saw teeth with improved quality and durability for head saws and edgers have been announced by Pacific Saw & Knife Co., 910 S. E. Stark, Portland, Ore. Called "Tiger Teeth", the saw bits are made by an electronic process that impregnates the steel with chromium and puts a hardened edge

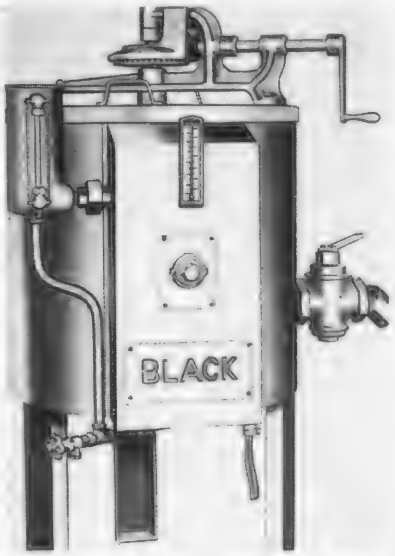
on the parent metal without plating of any kind.

The teeth reportedly do not chip, fracture, or break, and edges maintain sharpness and respond well to sharpening. The Portland firm also specializes in manufacture of carbide-tipped saws and groovers.

Glue Preparer Timer

A simple device to save production time by automatically turning on the heat in glue preparers at any specified time is now being manufactured by Black Brothers, Mendota, Ill. The firm manufactures standard production sizes of Hot Glue Preparers, from 2½ to 125 gallons, and is now installing a synchronous motor type unit, with magnetic contactor, for automatically turning on the heat at any predetermined time from 0 to 30 hours.

Accurate timing and dependable operation are reported assured by the synchronous motor which has a totally enclosed gear train and sealed-in lubrication. Requiring no winding, the operator merely has to set the pointer for the desired time. The larger pointer can be turned in either direction without damaging the instrument.



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Gives 100% inspection of moving veneer, lumber, core and dimensional stock, paper, fibreboard and related products. Automatically rejects any material outside the proper moisture limit. Eliminates poor glue bonds, warpage, splits, dimensional change and other moisture-induced "fall-downs." Dryer schedules may be adjusted to peak performance. A production line machine, Laucks SENTRY ® gives continuous and highly accurate control—permits safe speed-ups through entire production cycle. Write TODAY for free brochure.

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Sand flat work, mouldings and built-up pieces extra smooth, quick on the OLIVER

New variable speed drive prevents "burning" of wood

Here's a most useful Flat and Moulding Sander that also sands built-up pieces up to 12" high on table. A variable speed drive gives belt speeds from 2000 to 6000 f.p.m. Slower belt speeds prevent "burning" of wood by worn or "loaded" belts. Also available with motor-on-shaft drive for belt speed of 4500 f.p.m. Sands work 36" x 72". Write for Bulletin No. 184-V.

Oliver makes an extensive line of production Belt, Disk and Drum Sanders

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FPRS News-Digest, Continued

Air-Powered Strapping Machine

An air-powered strapping machine that automatically tensions strapping and then seals and cuts it off is announced by Signode Steel Strapping Co., 2600 North Western Ave., Chi-

cago 47. The machine provides uniform, predetermined tension which may be adjusted up to 1600 lbs. It is designed for use with 5/8or 3/4-inch strapping.

Automatic Nailer

Introduction of the Trojan-5 model Auto-Nailer has been announced by Auto Nailer Co., Atlanta, Ga. The machine, which cuts and drives nails equivalent in length to a five-penny nail, is of all-welded steel construction. It features improved controls for flexibility in changing from one type of job to another.

The firm now offers four automatic nailing machines, with nail sizes ranging from 1/4 inch to 1 3/4 inches and

15–21 gage. The nails are cut from a reel of knurled wire, with lengths adjustable. The machines will cut blunt, needle-point, or headed nails; will clinch, brad, or start the nails for later hand driving.

Special features include a driver to extend the countersink from flush to 9/64 inch, and an adjustment permitting driving the nail curved for those who do close-to-edge nailing.

NEW PUBLICATIONS

Wood Handbook. Superintendent of Documents, Government Printing Office, Washington 25, D. C. $2 Issued by U. S. Forest Products Laboratory, this enlarged and completely revised handbook is recognized as outstanding reference book on properties and structural uses of wood. Contains basic information on new materials and processes, including sandwich construction, plywood and other cross-banded products, building fiberboards, and modified woods and paper base laminates. 528 pp.

What You Should Know About Lumber. National Lumber Manufacturers Assoc., 1319 18th St. N. W., Washington 6, D. C. Lumber selling aid prepared especially for do-it-yourself enthusiasts, home owners, students, housewives, and others who buy or influence the purchase of lumber and wood products. Single copies: $.10; in bulk: $.07 each.

Recent Publications. Organization for European Economic Co-operation, 2000 P St. N. W., Washington 6, D. C.

Lumber-Value Meter for Central Hardwood Sawlogs. Station Note 89. Central States Forest Experiment Station, Columbus, Ohio.

Findings and Recommendations of the Michigan Natural Resources Conferences. Sponsored by Michigan College of Mining and Technology, Michigan State U., and U. of Michigan. Published by Michigan State U., East Lansing, Mich.

Cost Accounting Manual for Furniture Manufacturers. Southern Furniture Manufacturers Assoc., High Point, N. C. Guide to current methods and practices in furniture cost accounting, the principles of which may be followed in revising unsatisfactory methods or in tailoring a system to fit individual needs.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

Storage and Handling of Lumber (at Wholesale and Retail Yards and Consumer Plants). E. C. Peck. Report 1919. Covers outdoor and indoor storage, piling methods, manual and mechanical handling.

The Manufacture of Veneer. Report 285. General, non-technical description of the processes involved in making veneer. Rotary cutting, slicing, sawing, and drying of veneer are discussed briefly.

Supplement to Analysis of Long Cylinders of Sandwich Construction under Uniform External Lateral Pressure: Facings of Moderate and Unequal Thicknesses. M. E. Raville. Report 1844-A.

Stresses Induced in a Sandwich Panel by Load Applied at an Insert. W. G. Youngquist and E. W. Kuenzi. Report 1845.

Simplified Method of Selecting and Designing Package Cushioning Materials. R. E. Jones and W. J. Jones. Report 2031.

Purified Hardwood Pulps for Chemical Conversion. II. Sweetgum Prehydrolysis-Sulphate Pulps. F. A. Simmonds, R. M. Kingsbury, and J. S. Martin. Reprint from TAPPI.

Effect of Speed of Test on Bending Strength of Insulation Fiberboard. Wayne C. Lewis. Reprint from TAPPI.

EMPLOYMENT SERVICE

Positions Offered

No. E 208—Chicago firm has opening for recent college graduate trained in chemistry and wood technology. Position entails formulation, development, and technical service work on furniture finishes.

No. E 209—Recent college graduate in forestry, wood utilization or wood technology wanted for training in management position in wood preserving industry. Salary $300 to start.

No. E 210—Adhesives company seeks recent graduates for sales training positions in Southeast. Training program and excellent starting salary.

No. E 211—Progressive Eastern hardwood distribution yard seeks recent graduate or experienced lumber salesman for sales territory in New Jersey and surrounding areas.

No. E 213—Large wood preservation company, plants throughout U. S., seeks young chemists or chemical engineers.

No. E 214—Lumber mills, headquarters Los Angeles, seek experienced supervisory and operating personnel. Consider applicants in age 40–50 bracket.

No. E 215—Large, diversified West coast forest products company, headquarters San Francisco, seeks experienced market analyst. Should have engineering, wood technology or forestry background. Excellent starting salary.

No. E 217—Midwest furniture plant seeks high grade time-study engineer. Should be forest products technologist.

No. E 218—Eastern furniture company seeks experienced lumber grader who can also buy lumber. Will be in charge of lumber shed and will determine kind and grade of lumber to go with each production order.

No. E 219—Chemist wanted with experience in the chemistry of wood and wood finishes. Salary open. Location, Pacific Northwest.

Employment Wanted

No. 187—Young executive, M. S. in utilization plus 10 years technical production and sales experience in hardwood plywood, structural laminates, and millwork. Age 33. Will locate anywhere.

HELP WANTED

Organic Chemist with Knowledge of WOOD OR CELLULOSE

Position open in research on the chemical modification and processing of wood. Location suburban Pittsburgh, Penn. Central Research Laboratories of company which is leader in the field of wood treatment. Salary commensurate with education and experience. Send complete resume of education, experience, references and salary desired.

Reply to Employment Service—213
Forest Products Research Society
P.O. Box 2010, University Station
Madison 5, Wisconsin

No. 300—Chemical engineer, age 38, and 14 years experience in research and developing particle boards seeks west coast position. Requires $9,000 minimum.

No. 321—Production or marketing position desired by Penn State graduate student. Holds B.S. in forestry, will receive M.F. in January, 1956. Will locate anywhere but prefers East.

No. 323—Man with B.S. in Forestry, age 54, desires supervisory or technical work in lumber yard or woodworking establishment. Broad knowledge of grading, both hard and softwoods; experience in pre-fab housing. Can handle men, has limited selling experience. Desires Midwest.

No. 325—December 1955 graduate of Colorado A & M College is seeking position in selling, buying or utilization industry offering a training program. Will receive B.S. Degree in forest utilization. Prefers Midwest or West. Single, age 22.

No. 332—Young man, B.F. in forest products, B.S. in commerce, seeks position in Western lumber or plywood industry. Experienced in research and retail lumber. Age 26.

No. 333—Manager, commerce and legal degrees, age 41, 20 years experience in fine hardwoods and veneer industry as mill manager and assistant sales manager, seeks Midwest position in specific locale. Details upon request.

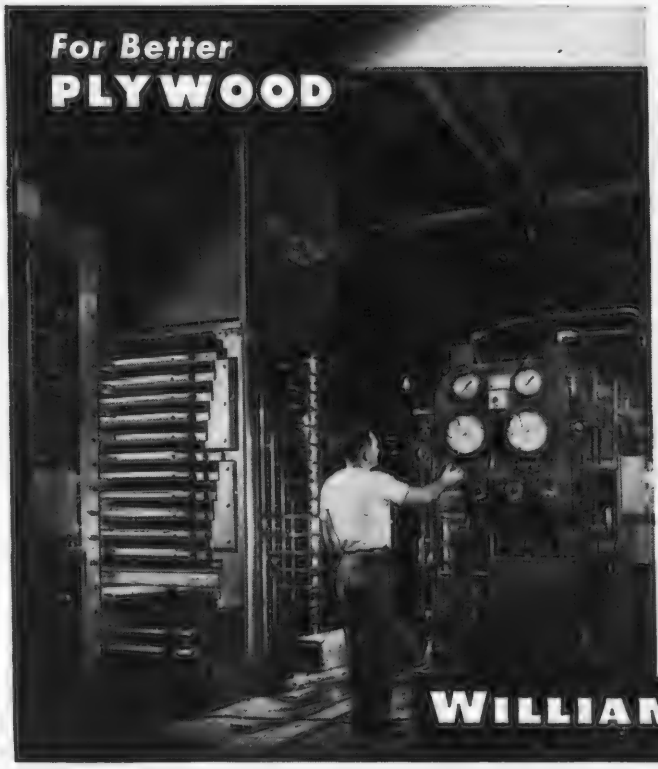
No. 334—Saw filer from African Gold Coast trained in United Kingdom desires additional temporary industrial trainee experience in U. S. Knowledge of grading, preservation, and classification of timber.

No. 335 — Young man, age 32, single, seeks position in furniture manufacturing. Graduate Vanderbilt University. For three years, head of own firm in wrought iron gift field.

FOREST PRODUCTS RESEARCH

Group leader for Forest Products section in new research center. Ph.D. or equivalent in wood technology or paper and pulp practice necessary. Strong background in chemistry and understanding of polymeric materials desirable. Excellent growth potential with a new division of an old and reliable company. Group is being newly formed and will concern itself with basic approaches to the overall field of forest products. Reply in confidence enclosing complete resume to

The Borden Company,
Chemical Division,
Philadelphia Research Laboratory,
P. O. Box 9524,
Philadelphia 24, Pa.



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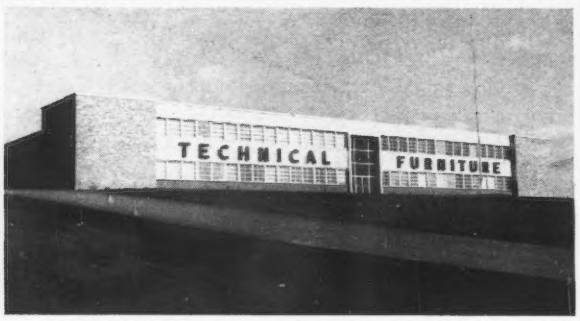
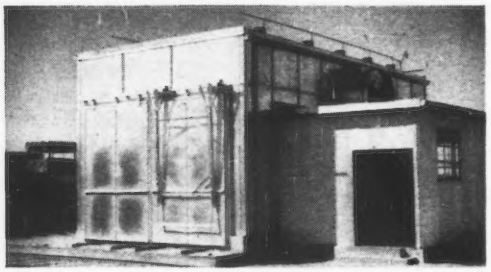


AGAIN, TECHNICAL CHOOSES

STANDARD!

● The Technical Furniture Company has purchased a *second* Standard Prefabricated Dry Kiln for its new plant in Statesville, N.C. Like the first (shown below), it provides high performance and complete control of temperature and humidity conditions. Circulation of air is effected by Standard's well-known direct-driven, internal-fan system . . . *used successfully for years in thousands of installations!*



Technical's two Standard Prefabricated Dry Kilns have doors at both ends. Each kiln will hold approximately 20,000 bd. ft. of lumber. All kiln controls are located at the side, at ground level.

WE SELL THE FIRST *Standard...*
Performance SELLS THE REPEATS!

For additional information, write for your FREE Prefab Dry Kiln booklet!

Manufacturers of Internal Fan Kilns

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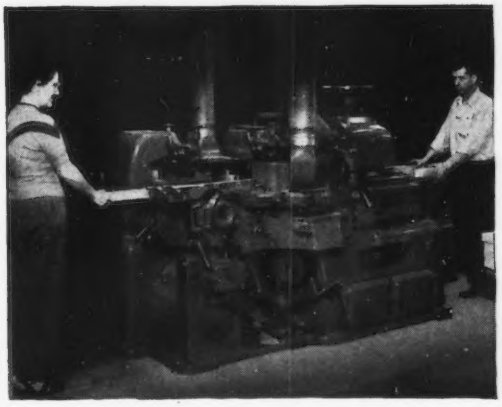

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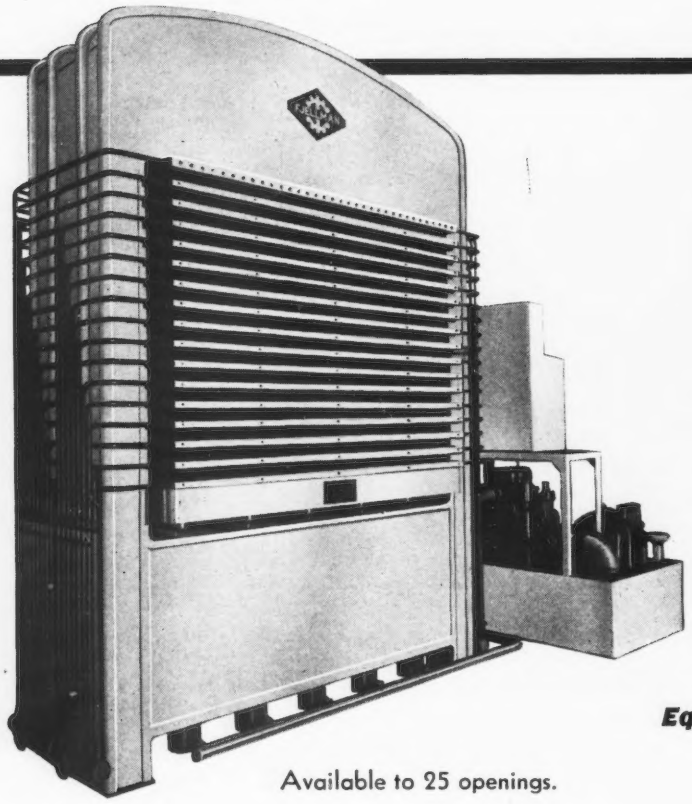

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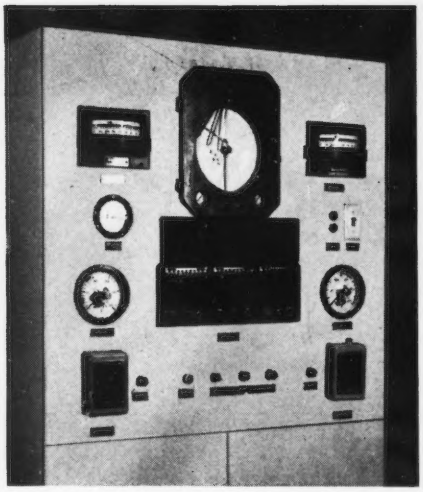

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